POWER PLANT ENGINEERING

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The American Printing Co.'s Plant at Fall River

A FINE EXAMPLE OF A POWER PLANT SERVING A LARGE TEXTILE PLANT

IN CONNECTION WITH the much discussed question of superpower stations and large interconnected power systems, one factor that should receive consideration is the necessity for proper co-operation between the large power systems and the industrial power plants. Unless proper co-operation is secured between these two types of power producers, our national fuel resources will not be utilized to their greatest advantage.

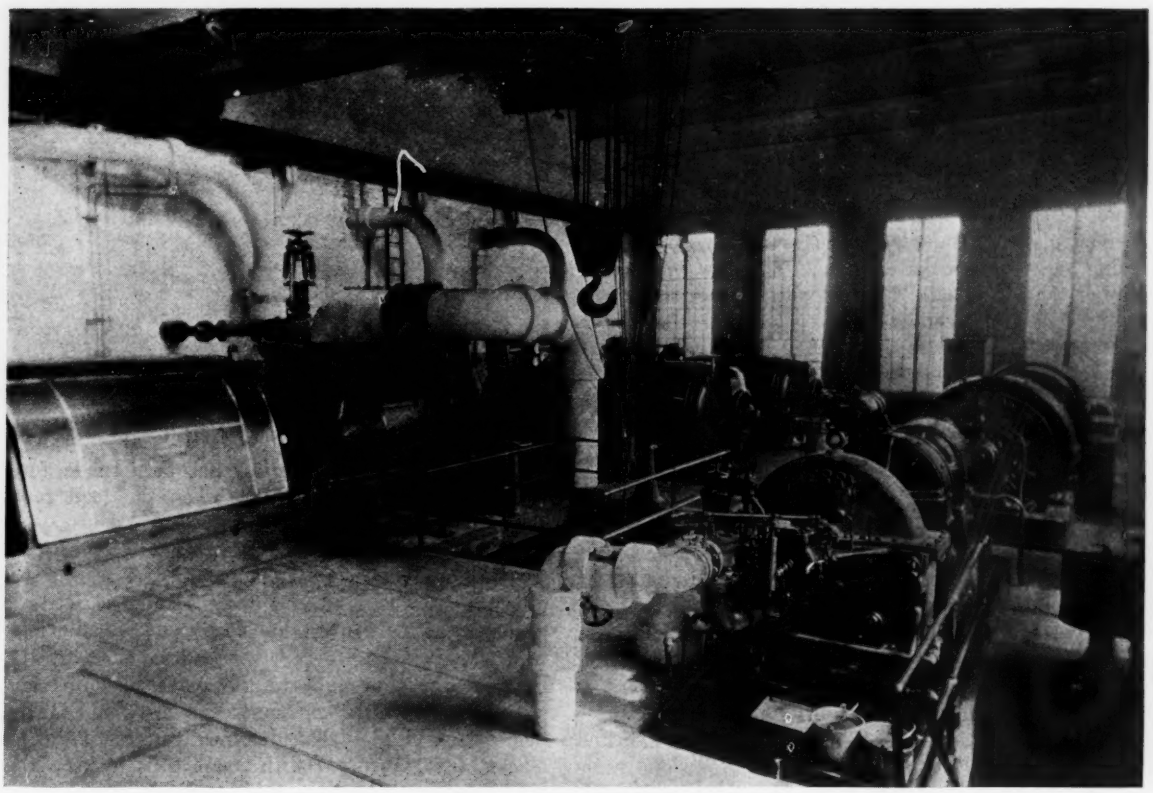


FIG. 1. A GENERAL VIEW IN THE TURBINE ROOM

This co-operation consists mainly in an arrangement whereby power will be interchanged between the large power system and the industrial plant in accordance with their respective needs and the times of maximum and minimum demand. An arrangement of this kind will result not only in a better load factor for each party concerned, but will also bring about a more efficient utilization of fuel.

An excellent example of an arrangement of this kind may be found in the plant of the American Printing Co. at Fall River, Mass. This plant, which is one of the largest textile plants in New England, is served with power, light and heat from its own power plant. The electrical system, however, is interconnected with the lines of the local public service company so that in case of an excessive load on the electrical system at the plant, power may be taken from the public service company's lines, while on the other hand, if the load is

light, power is delivered to the public service company's system. In referring to load, we mean, of course, the electrical load. To be more exact, the electrical load at this plant is governed by the amount of steam used in the mills for manufacturing purposes and in process work. At times when the steam demand exceeds the electrical load, surplus power is supplied to the city lines; but when the demand for steam is less than the electrical load, power is taken from the city lines. The reason for using this arrangement and the details of its working will be more fully explained further on in this article.

Power Supply

The plant of the American Printing Co. is composed of two main divisions, i.e., the cotton mill division and the printing division. There are also two power

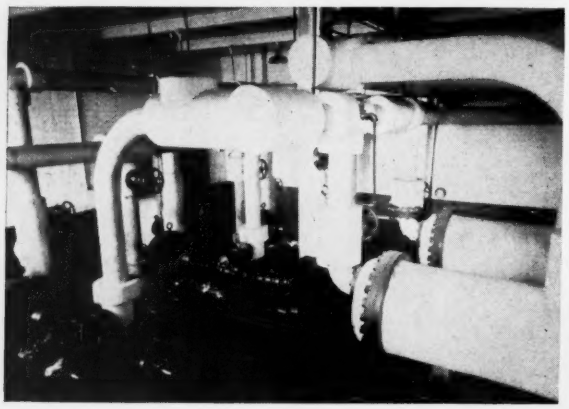


FIG. 2. A CORNER OF THE FUEL OIL PUMP ROOM, SHOWING PUMPS AND HEATERS

plants, an old plant serving the cotton mill division and the new plant (with which this article is concerned) serving the print works division. The new plant also supplies the cotton mill division with all electric power for lighting and electrical drive. More of the power in this division, however, is supplied from the old plant through mechanical drive.

There are 63 horizontal return tubular boilers at the old plant, all of approximately 150 hp. each, and 10 of 275 hp. each, all oil fired. This old plant is entirely separate from the new plant and is essentially a part of the cotton mill division.

The New Plant

The new plant is a modern two-story building of brick, steel and concrete construction and lighted on all sides by large windows. The boiler and turbine room are on the same level with a dividing wall between. The electrical switching and transformer equipment is installed at one end of the building and occupies three floors, the control boards being at the top, the oil switch equipment in the middle and the high tension transformers on the ground floor.

The boiler room contains 10 Edge Moor water-tube boilers having a combined rated capacity of 6340 b.hp. In the turbine room there are four turbo generators of various capacities and two motor generator sets, delivering direct current. The combined generating capacity of the turbo generators is 10,200 kw.

Much of the steam generated is used for other purposes than the production of electrical energy, however, and as stated previously, the amount of electrical energy generated in the turbine room is dependent upon the demand for steam in the mill. This accounts for the relatively large amount of boiler capacity as compared to the rated turbine capacity.

Steam Producing Equipment

Steam is generated at a pressure of approximately 200 lb. per sq. in. in 10 four-pass, vertical baffle Edge Moor water-tube boilers, four of which are rated at 685 hp. and the other six at 600 hp. All boilers are oil fired and all are fitted with Foster superheaters. Of the six, 600 hp. boilers, four are equipped with Green fuel economizers. Under normal operating conditions, 125 deg. superheat is carried.

Oil Burning System

Each boiler is fitted with four Peabody oil burners to which oil is delivered at a pressure of 250 lb. and at a temperature varying between 250 and 270 deg. F.

The oil pumping and heating equipment is installed in a separate room in the basement below the boiler room. For heating the oil to the temperature required at the burners, two Griscom-Russell, three-pass oil heaters are provided. These are heated by live steam and are capable of handling 40,000 lb. of oil per hr., each. The combined capacity of these heaters is, therefore, 80,000

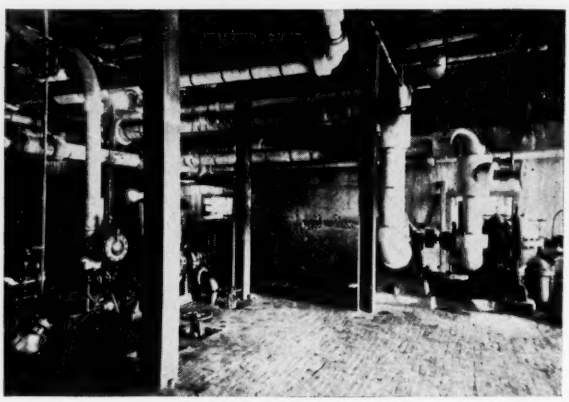


FIG. 3. FEED PUMPS AND ECONOMIZER PUMPS IN BASEMENT

lb. of oil per hr. Allowance has been made for the installation of another heater when the load requirements of the plant demand.

The condensate from these oil heaters is delivered to the feed water heater, as make up. A safety seal is interposed between the oil heaters and the feed water heater to guard against the danger of oil entering the feed water system.

Fuel oil is brought to the plant by ships and is stored in two 350,000-gal. concrete storage tanks installed below the ground at some distance from the power plant. These tanks are fitted with steam coils to keep the oil warm and in the proper fluid condition.

Oil from the storage tanks is delivered to the oil pump room in the power house through a 6-in. underground line about 1200 ft. long. The 2-in. steam line furnishing steam to the storage tank coils is installed alongside of the 6-in. oil line. Lagging consisting of felt with an outside covering of roofing paper is wrapped

around both lines, so that the heat radiated by the steam line is utilized in heating the oil in the oil line. A pressure of about 20 lb. is maintained on the steam line.

Two Worthington duplex pumps, 10 by 6 by 10 in. located near the oil storage tanks pump oil from the tanks through the 1200 ft. of 6-in. line referred to above into the suction of the oil pumps in the boiler house. These pumps maintain an oil pressure in the line of about 10 lb. and have a capacity of 85 g.p.m.

In the pump room there are three Quimby quadruplex screw pumps direct connected to Terry turbines. Two of these have capacities of 85 g.p.m. against a pressure of 250 lb. and are driven by 65-hp. turbines. The third pump is a small one, being driven by a 15 hp. turbine and having a capacity of 20 g.p.m. The latter is used for carrying the night load. From these three pumps oil is sent through the heaters and then directly to the burners under the boilers.

The Boilers

The boilers were equipped originally with Riley 8-retort under-feed stokers, but when the price of coal began to soar and as it become increasingly difficult to obtain, the entire plant was converted to the use of oil. This has proved so satisfactory that at the present time the management has no intention of going back to the use of coal.

The use of oil in the New England states may seem a bit strange on first thought; but after considering the fact that both coal and oil are equally scarce in this section of the country and that both of these fuels must be imported from other localities, it will be evident that the question of the most suitable fuel resolves itself into a problem of transportation. Since oil is a commodity easily transported by ships it is thus not strange that stations located on tide water should tend towards the use of oil fuel. At this plant, Mexican fuel oil is used. This runs about 12½ to 13 deg. Baumé, at 60 deg. F., contains from 3½ to 4 per cent sulphur and has a heat content of 18,300 B.t.u. per lb. With oil having these characteristics, an average evaporation of 13½ lb. of water per pound of oil is secured.

Boilers numbered 1 to 6 inclusive, that is, the 600-hp. boilers, each have heating surfaces of 6094 sq. ft. Those numbered 7 to 10 inclusive each have 6836 sq. ft. of heating surface. The furnaces on all boilers are about 12 ft. square and 12 ft. high.

Forced draft is supplied to all furnaces by four Green, radial flow fans, driven through reducing gears by 55 hp. Terry steam turbines. Space has been left for two more fans to be installed at some future time.

FIG. 5. THE BOILER ROOM

Each fan will deliver 43,000 cu. ft. of air per min. at 5 in. pressure, giving a combined capacity for the four units of 172,000 cu. ft. per min. All forced draft fans discharge into one common air duct from which the feeder ducts lead to the individual boilers. These feeder ducts are fitted with a balanced damper, so arranged, that if for any reason the forced draft fails, the dampers will open automatically. The boilers will thus go on natural draft.

The air through the feeder ducts is controlled by dampers operated by a balanced draft apparatus. The speed of the fans is varied automatically to maintain a constant pressure in the air duct.

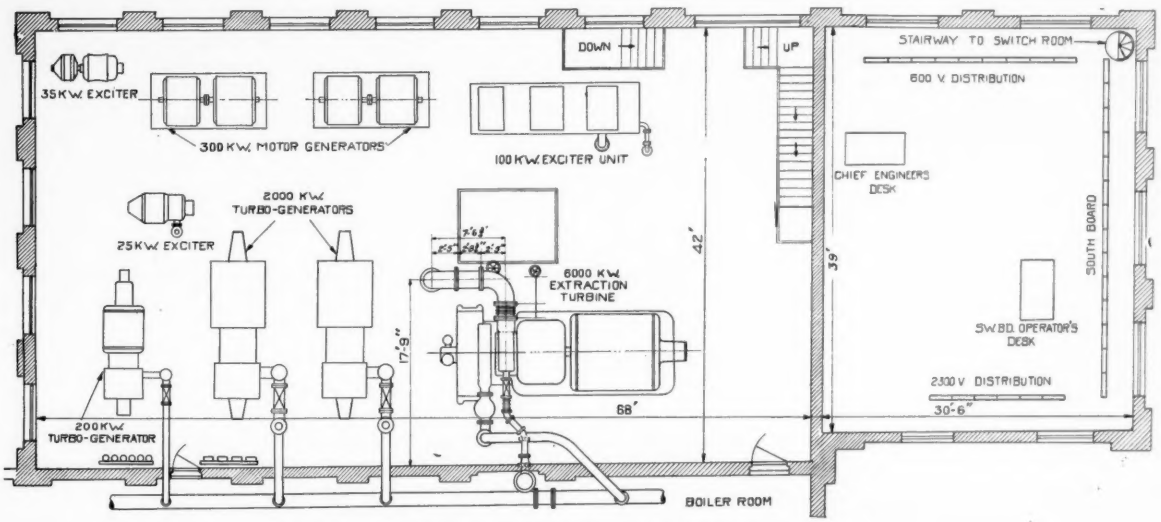


FIG. 4. GENERAL PLAN OF TURBINE ROOM AND SWITCHROOM

In the case of the four boilers having economizers, two Green induced draft fans are provided. These are driven by 57½-hp. Terry turbines through Westinghouse reducing gears.

Two stacks are provided; one, a 150-ft. stack for the 600-hp. boilers and the other (a new stack), a 200-ft. radial brick chimney for the four 685-hp. boilers. The latter has a 14-ft. bore and was built by Ballard Sprague & Co., Inc.

Feed Water

Feed water for the boilers is obtained from the Quequechan River. The water in this river is used by a number of different plants further upstream and at some from the river or from the plant's water supply system or from the city mains.

For treating the feed water two open type heaters are provided: one, a Hoppes heater of 300,000 lb. per hr. capacity and the other a Warren Webster heater with a capacity of 165,000 lb. per hr. Both heaters are supplied with exhaust steam from the steam driven auxiliaries.

Two 5-in. Buffalo economizer pumps, driven by 60-hp. Terry turbines take feed water from the heaters and deliver it to the economizers at 90 lb. pressure.

Water leaves the feed heaters at 210 deg. F. and the economizers at 240 deg.

Feed water is put into the boilers by three Jeansville

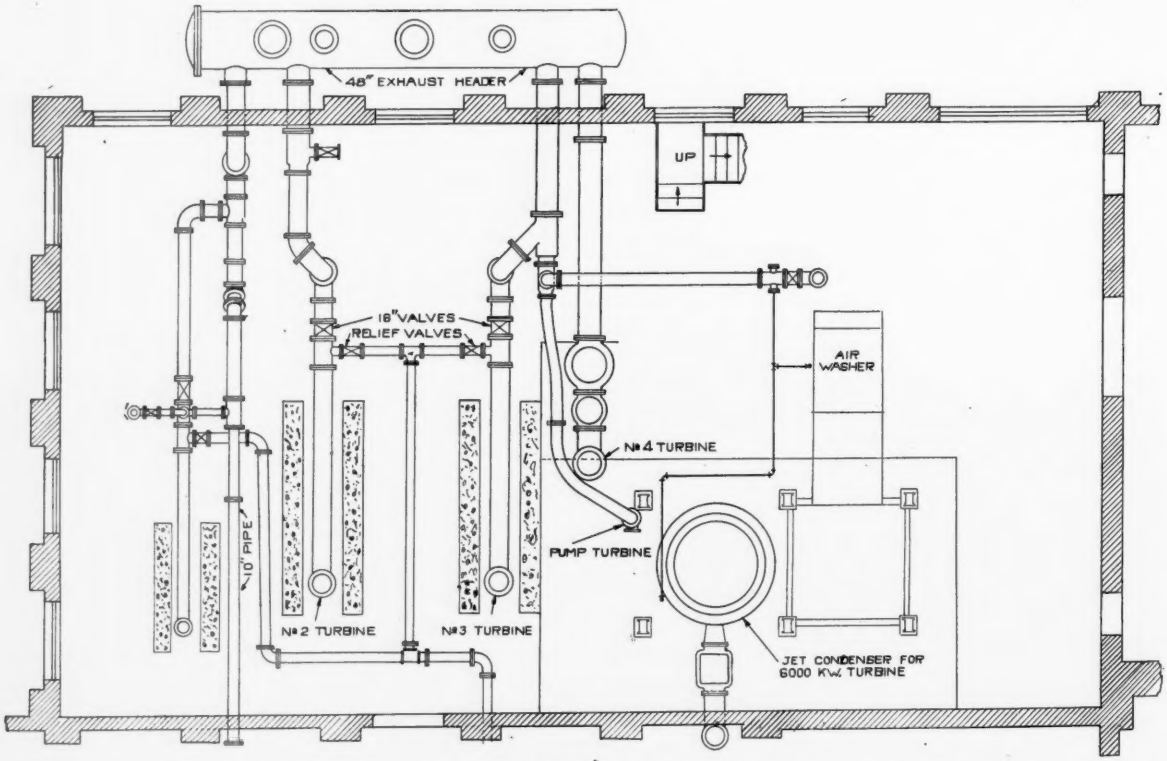


FIG. 6. SHOWING EXHAUST STEAM PIPING SYSTEM IN BASEMENT OF TURBINE ROOM

of these plants the water is softened to meet the individual needs. The result is that when the water reaches the plant of the American Printing Co. it is sufficiently soft to be used in the boilers without harmful effect. Little or no scale forms and as the boiler tubes are turbined every 6 mo. with Roto mechanical tube cleaners, no difficulty is experienced in keeping the interior surfaces clean.

Three independent boiler feed lines are provided; one line to each boiler controlled by a Copes feed water regulator; one line for emergency purposes, and each boiler is also equipped with a 2½-in. Metropolitan injector. The latter are capable of supplying water to each boiler to enable them to operate at normal rating.

The water in the feed line controlled by the Copes regulators passes through either of two Venturi meters, one an 8 by 4-in. meter used on the day load, and the other a 4 by 1⅝-in. meter to handle the night load.

Water for the injectors can be taken either direct

double suction impeller type, centrifugal pumps. Two of these are 600-g.p.m. pumps driven by 115-hp. General Electric Co. turbines. The remaining one is a 1000-g.p.m. machine direct connected to a 200-hp., 2100-r.p.m. Terry turbine. All boiler feed pumps are controlled by Framingham differential pump governors by means of which the feed line pressure is maintained 30 lb. above the steam pressure.

The temperature on the feed water heaters and also on the fuel oil heaters referred to in connection with the fuel oil system is controlled by Curtis thermostats.

Boiler Accessories

Each boiler is fitted with three 4½-in. Consolidated Pop safety valves, and with two 2½-in. Homestead and Faber blowoff valves. Edge Moor soot blowers are used to keep the external surfaces of the boilers free from soot and dust.

Bailey boiler meters are provided for each boiler.

These meters record flue gas temperature, steam temperature, steam flow in per cent of boiler rating, and air flow through furnace. In addition to this, they also indicate furnace pressure. Under normal operating conditions, the air flow pen and the steam flow pen on these meters are set so as to run together at 17 per cent excess air and flat CO.

An Ashton 18-in. master steam gage is hung above the firing aisle as shown in the photograph, Fig. 5.

The Turbine Room

Electrical energy is generated by four turbo generators of varying sizes and types. The largest of these is a 6000-kw. General Electric condensing five-stage machine of the extraction type, operating under 190 lb. steam pressure at 3600 r.p.m. Steam is extracted from the intermediate stages at from 15 to 60-lb. gage pressure.

The turbine exhausts into a C. H. Wheeler Co. low level jet condenser served by a duplex driven condensate pump. The condenser is also equipped with two two-stage Radojets with inter- and after-coolers. This insures uniform high vacuum. The electrical end of the 6000-kw. machine consists of a 6000-kw., 80 per cent power factor, 2300 v., 1883 amp. General Electric generator.

The other three machines are of the non-condensing type, the exhaust steam being used in the mill for heating, etc. Two of these are 2000-kw. General Electric 3600 r.p.m. turbines direct connected to General Electric 600 kw., 1806 amp., 80 per cent power factor generators.

The remaining machine is a small unit, rated at 200 kw., also of General Electric manufacture.

Excitation for the above described generators is furnished by three exciter units, one a motor driven unit, one direct connected to the 200-kw. turbo-generator, and one a dual drive machine. The latter is a 100-kw. General Electric direct current generator, driven at one end by a 160-hp. Terry turbine and at the other end by a 150-hp. General Electric induction motor.

The motor driven exciter referred to is a 35-kw. machine driven by a 50-hp. induction motor.

Two motor generator sets are provided. These furnish all the necessary direct current power required for use on variable speed machines throughout the print works. These motor generator sets are of the same size and type and consist of 300-kw. Westinghouse 125/250-v. direct current generators direct connected to 435-hp., 600-v. General Electric synchronous motors.

The 6000-kw. turbo-generator and also the two 2000-kw. machines are equipped with American Spray Engineering Co. air washing systems, for cooling and cleaning the air to the generator windings. The washer on the large machine is capable of handling 20,000 cu. ft. of air per min., while those on the two smaller machines each have a capacity of 7500 cu. ft. per min.

A Bowser oil filter is provided to take care of the oil from all of the turbines. By means of a Kenney rotary pump attached to the filters, the oil in any one of the turbines may be changed in about 1½ min. All turbine oil is cooled by means of Schutte and Koerting oil coolers. The auxiliary oil pump on the 6000-kw. turbine is controlled by a Framingham pump governor, set at 5 lb. below the pressure of the main pump; the throttle on the auxiliary pump being wide open when the main pump is in operation.

Instruments

The turbines and associated equipment are provided with an excellent assortment of indicating and recording gages for keeping tab on the operating performance. Each turbine has its individual gage board fitted with pressure gages, and speed indicators. A general turbine room gage board conveniently located contains the following instruments:

1 Bristol steam pressure gage (recording).
1 Crosby steam pressure gage (indicating).
1 Taylor recording thermometer (temperature of discharge from steam traps).
1 Bristol recording pressure gage (boiler feed water).

Steam for Manufacturing Purposes

In a plant of this nature a considerable quantity of steam is used for manufacturing purposes. At this plant, therefore, an extensive steam distribution system has been installed, including both high and low pressure distribution lines.

Exhaust steam from the two 2000-kw. turbines, the 250-kw. turbine and from all steam driven auxiliaries is

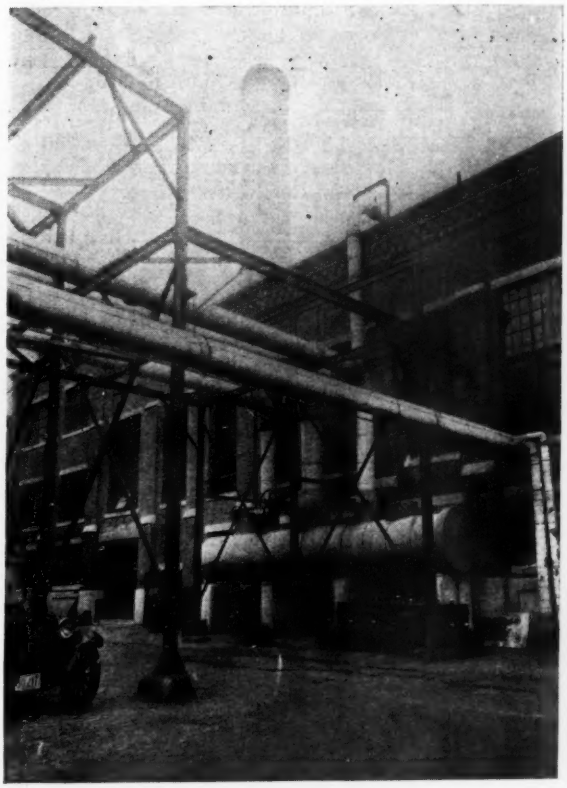


FIG. 7. AN EXTERIOR VIEW SHOWING THE EXHAUST STEAM HEADER AND OVERHEAD STEAM DISTRIBUTING LINES

delivered into a 48-in. welded steel header, installed outside of the building immediately adjacent to the turbine room. A 20-in. line extracting steam from the intermediate stages of the 6000-kw. turbine also feeds into this header. This header and associated piping is shown on the drawing Fig. 6 and may also be seen in the photograph, Fig. 7.

From this header or receiver, 20-in. overhead lines carry the steam at 15 lb. pressure to the mills where it is used for manufacturing purposes. Two 8-in. high pressure lines equipped with reducing valves supply the low pressure system with live steam in case of a shortage of exhaust steam.

The 20-in. extraction line from the 6000-kw. turbine is fitted with a 20-in. Schutte and Koerting non-return stop valve. The steam flow on the two high pressure lines and also on the 20-in. extraction line is measured by Republic flowmeters.

Electrical Features

All electrical control equipment is housed in a separate part of the building at one end of the turbine room. The control room, in which the main switchboards are located overlooks the turbine room so that the switchboard operator may conveniently observe the actions of the machines on the turbine room floor. The switchboard is divided into three sections, each section occupying one side of the room. Figure 9 shows the south and east divisions of this board.

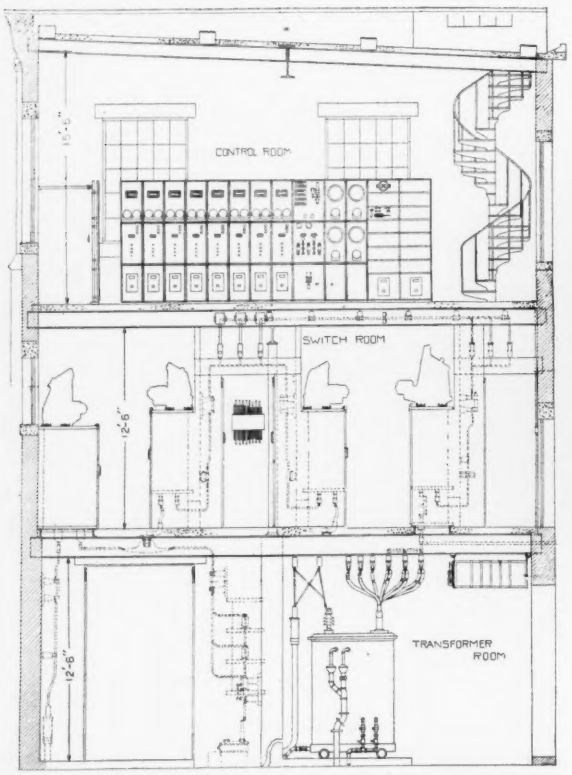


FIG. 8. SECTION THROUGH SWITCH AND TRANSFORMER HOUSE LOOKING WEST, SHOWING SWITCHBOARD ROOM, OIL SWITCH ROOM AND HIGH TENSION TRANSFORMER ROOM

The south board includes all the generator panels for 600 and 2300 v., the transformer switches for the 23,000-v. tie lines connecting with the Fall River Electric Light Co., and the exciter and regulator panels for the 2300 and 600-v. system. On this section of the board, all switches are of the remote control type, the switches themselves being located in the room below.

The east section contains the feeder panel for all 600-v. distribution, and the west section, all feeder panels for 2300-v. distribution. The latter also contains panels for the station emergency lighting which can be thrown over automatically to the 120-amp.-hr. storage battery which is always held ready for service.

Two panels on the west section are fitted with integrating and recording instruments for measuring the steam flow in various lines throughout the plant.

The control current for operating the remote control switches and signal systems is supplied from the storage battery. Klaxon horns and telephones are installed throughout the plant, thus insuring instant communication between the operating floor and the various control stations.

In the room below the operating or control room are located the various oil circuit breakers. These are of standard construction and do not require detailed description.

The transformers are located on the ground floor. The equipment here consists of three General Electric Co. oil cooled transformers with windings for 600 v., 2300 v. and 23,000 v. In this room are also located all the high tension busses and protective apparatus.

Electricity is interchanged between the plant and the lines of the Fall River Electric Light Co. as explained in the first part of this article; the meters reading both ways.

No description of this plant would be complete without mentioning the excellent system of records kept

FIG. 9. PHOTOGRAPH SHOWING SOUTH AND EAST SECTIONS OF SWITCHBOARD

upon the operating performance of the plant. These reports are turned in daily to the superintendent of power, who uses them in compiling his monthly and yearly record sheets.

In the chief engineer's office there is also installed an elaborate card index system in which all meter readings are kept for daily reference.

Conclusion

This power plant, including buildings, choice and arrangement of equipment, piping, wiring, etc., were designed by and constructed and installed under the supervision of the Engineering Department of the American Printing Co. For privileges extended and assistance rendered in the preparation of this article we are indebted to the engineers of this department to whom credit is hereby extended.

Adapting Coal to the Furnace

Outline of Process for Quantity Production of Carbonized Coal. By Osborn Monnett

FUEL engineers are concerning themselves more and more with the problems of the immediate future with respect to fuel for large power plants. Heretofore there has been no question except to burn raw coal with no preparation except crushing to meet certain types of stokers. Now the preparation of coal in large quantities for central station service is engaging serious consideration. The question is, in what form will coal ultimately be burned in large stations.

Raw coal is the cheapest form in which coal can be burned. Any addition to the cost of coal by way of preparation imposes a corresponding penalty in obtaining higher efficiency to offset the increased cost. Preparation of coal should be justified when it is desired to work up deposits that, owing to high ash or moisture, are not capable of being burned to advantage in the raw state. Also the refuse "bug dust" produced at the mines in large quantities should be prepared in some way for utilization in the power plant field.

Powdered coal has been favored with some important installations and is being considered for others. Prepared in this way it is still in the raw state and in an expensive form, being correspondingly penalized. Moreover the valuable constituents of the volatile matter are burned while they might be more advantageously applied to other uses. The ash content of coal in any process of preparation is a serious factor the same as it is when raw coal is burned. The lower the ash the more favorable the result will be when using powdered coal. It is probable that some coals will run so high in ash as not to give satisfactory results with this method of preparation.

Carbonization of coal whereby certain by-products are removed, offers an attractive field in fuel engineering. The higher the temperature of carbonization, the greater the yield of by-products but the less usable the resulting fuel becomes for certain purposes. Coal carbonized at 2000 to 2200 deg. F. leaves a coke containing about 1 per cent volatile which is physically adapted to blast furnace conditions but when applied to burning in power plant furnaces is rather difficult to control. When used for domestic purposes, it is very difficult to get owners to take the time and trouble to learn how to burn such fuel. The ideal domestic fuel should contain a certain amount of volatile matter, so that the fuel will ignite readily, burn under control and operate satisfactorily with low rates of combustion. With the scarcity of anthracite which is developing as the country expands, large territories must necessarily depend on the high volatile coals in their immediate neighborhood. This creates a serious situation from the smoke standpoint and also from an economic standpoint, as it requires a certain amount of changes in methods to burn high volatile coal satisfactorily. If a fuel can be produced containing about 10 or 12 per cent volatile, it could be burned in the furnace found in homes, without change in methods; would solve the smoke problem insofar as it applies to domestic equipment and at the same time result in an appreciable amount of by-products being returned to industry.

A ton of coal carbonized at 750 deg. F. will yield 7/10 of a ton of coke containing 10 per cent volatile and 20—30 gal. of tarry oils, benzols, phenols, etc. It has been said that the value of these by-products will amount to $2.50 and up per ton of coal depending on the degree of refinement applied in working up the crude material. This material is too valuable to use as a fuel and is the part of the fuel which makes most of our trouble in combustion processes. Carbonized coal returns by-products to pay for the process and does not penalize the furnace to pay for the operation.

There are no low temperature plants running commercially in this country, but a number of schemes are under development. In general, the method is to follow the by-product coking operations for high temperature work, such as filling a retort, applying heat, distilling the by-products, emptying the retort, refilling and repeating the process. This is a slow procedure and limits the tonnage that can be handled thereby increasing the first cost of plant. Other processes have attempted the movement of the fuel through a heated zone, entering one end and out the other in an effort to increase tonnage and cut down the first cost. The efficiency of heat transfer on all of these processes is low. The gas evolved, however, is ordinarily sufficient to generate the heat necessary to continue the process. The volume of gas is, of course, much lower than with high temperature processes, but at the same time it is richer in quantity. In a true low temperature carbonization process, the gas itself can be considered a by-product and if there is enough produced to carbonize the fuel even on a low efficiency basis, it should be satisfactory.

It would seem that the ultimate process for low temperature carbonization should be continuous where the coal is fed in at one end and comes out carbonized at the other.

In the ideal installation it should be easy to handle from 750 to 1000 T. of coal per hour per unit.

The coke produced would have all of the original ash in the coal, which percentage would be increased by the amount of volatile matter and moisture driven off. Experiments have shown that it is possible to reduce the ash content in coal, either by washing or by an air separating method, something like those used in metallurgical work. Washing to reduce the ash would be rather unsatisfactory because all the moisture would necessarily have to be driven off again before carbonization could take place. The other method, that of dry air cleaning, would operate by allowing the ground coal to flow by gravity over shaking tables through a blast of air, the ash segregating and being removed.

If such a process could be used preliminary to carbonization, the resulting coke should not have more than the original percentage of ash in the coal sample. The result would be a concentrated, smokeless, highly efficient fuel which would be desirable for operations not only in domestic equipment but in power plants and other industrial uses. In the West there is a large amount of low-grade fuel high in moisture which it is practically impossible to store and transport. Such a fuel could

be ground, deconcentrated of ash, have its moisture removed and sent out in a form which could be shipped, stored and used to advantage. In order to obtain the necessary mechanical structure to permit handling, some coals, especially those of the West, would require briquetting in some form. The pitch produced by distillation would in most cases furnish all the binder required. Railroads should be able to use large quantities of such concentrated fuel either in increasing their radius of action or in increasing the efficiency of operation. By varying the temperature of distillation, the amount of volatile matter left in the fuel could be varied to suit the industrial use to which it might be put. Altogether the subject is attractive, thoroughly in line with the ideas of conservation of natural resources and experiments under way at the present time give promise of successful applications of the idea.

RESULTS OF CARBONIZATION OF A WESTERN COAL

Coke	
Pounds per ton	1360
Per cent yield	68
Gas	
Cubic feet per ton	3240
Cubic feet per pound of coal	1.62
Tar	
Pounds per ton	189
Gallons per ton	23
Ammonium Sulphate, pounds per ton	10.6
Analysis of Gas	
Carbon dioxide	5.0
Ethylene	7.1
Hydrogen	27.8
Carbon monoxide	6.4
Methane	43.7
Ethane	7.9
Nitrogen	2.1
B.t.u. per cubic foot	858

Analysis of Coke		Proximate Analysis of Original Coal	
Per cent moisture	1.39	Moisture	4.99
Volatile	12.32	Volatile	36.27
Fixed carbon	76.85	Fixed carbon	48.56
Ash	10.18	Ash	9.44
Sulphur	1.09		
Air dry loss	0.5		
B.t.u.	13,090		

Ultimate Analysis of Original Coal	
Sulphur	1.43
Hydrogen	5.34
Carbon	69.29
Nitrogen	1.52
Oxygen	12.24
Air dry loss	3.1
B.t.u. commercial	12,481

Cement for Cast-Iron

A CEMENT for cast-iron that will stand as severe test as the blows from a steam hammer can be made by mixing equal parts of sulphur and white lead with about 1/6 portion of borax.

This powder should be moistened with sulphuric acid and applied in a thin layer between the two surfaces of metal, which should be lightly pressed together. The result is a hard tight joint. C. C. BROWN.

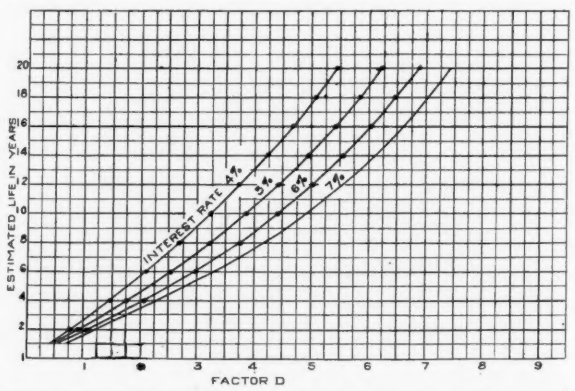
Determining Money Value of Efficiency

BY PAUL F. CHRISTOPHER

IT IS always interesting to make comparisons on an efficiency basis, but it is not always an easy thing to do. The simple calculation of efficiency does not present any serious difficulties, but when it comes to evaluating or capitalizing the greater efficiency of one machine over another the methods become more formidable, and the possibilities of drawing incorrect conclusions multiply.

It is an odd circumstance that manufacturers and their customers should be at loggerheads over the question of efficiency. The manufacturer wants to improve his product, he employs expensive engineers, maintains an expensive research laboratory, and scours the earth for the best materials and methods. When he has succeeded in making a better machine it is unavoidable that it should cost more to build, and therefore should be sold for a higher price. But how much higher? The customer wants the best article his money will buy, but how far should he trust to the judgment of the manufacturer?

This is the field on which a thousand industrial battles are waged every day. The combatants are graded according to strength and viciousness, from the



CURVES FOR DETERMINING FACTOR USED IN PURCHASER'S EQUITY FORMULA

manufacturer who enjoys a complete monoply in his field and tosses his product into the ring with the injunction to take it or leave it, to the hard-shelled purchasing agent who never bought a nickel's worth of goods except on a price basis. Most of us fight it out on some middle ground and get along fairly well by making mutual concessions, without breaking off diplomatic relations.

No argument is necessary to establish the fact that an efficient machine costs less to run than an inefficient machine. It is an everyday problem to figure out the loss in dollars and cents caused by the poorer machine. Many engineers are inclined to stop at this point, however, on account of the rather complicated formula it is necessary to solve if further enlightenment is desired. To avoid the necessity of resorting to tables of logarithms of long, tiresome pencil and paper work, the curves shown in the figure have been drawn so that two slide rule operations will show just how much more one can

afford to pay for a better motor, pump, blower or other apparatus.

The first step is to determine the annual loss in dollars and cents. This loss represents the earning power of a given sum of money invested at whatever interest the banks will pay, or the interest money earns in your business, if that figure is available. Divide the amount of money which will be lost, on account of the inefficient machine, by the rate of interest, to find the sum of money which should be invested to offset this loss. From the curves, determine the D factor from the rate of interest and the life of the machine. Multiply the D by the figure obtained above to arrive at the difference in the value of the two machines. Expressed as a formula, this relation would read as follows:

$$E = S \div R \times D$$

E = purchaser's equity.
S = sum of money customer stands to lose anuually.
R = rate of interest.
D = factor determined from the curves.

The purchaser's equity means the part he owns before he spends any money. That is, if two machines are offered at the same price, but one is more efficient than the other, he already owns part of the inefficient machine to the extent of the amount figured from the above formula. To get around this situation the manufacturer of the inefficient machine reduces the price of his apparatus, or should reduce it, at any rate. By the method outlined it is possible to decide whether the price is right.

A short example of the way this method works may be of interest. Assume that a study of two motors shows that one will cost $100.00 more, per year, to run than the other. Bank interest is found to be five per cent and this type of motor is generally credited with fifteen years of useful life. $100.00 ÷ 0.05 = $2000.00. From the curves D is found to be 0.52. Fifty-two per cent of two thousand dollars is $1040.00 which is the difference which should exist between the prices of the two motors.

In practice it is not often that the problem is as clear cut as this, but this method should enable curious engineers to get a fairly good line on the apparatus they are asked to buy.

The curves are calculated from the formula

$$D = \left(1 - \frac{1}{(1 \div R)^n}\right);$$

in which D = multiplier required, R = rate of interest, and n = number of years machine is expected to run.

Looking Ahead in the Fuel Industry

A Discussion of America's Most Important Problem and Suggestions as to Its Solution. By Floyd W. Parsons

THE QUESTION of an adequate fuel supply is the first, the most important and the most vital problem in the United States today. Speaking before a large gathering of engineers at the Western Society of Engineers in Chicago, Floyd W. Parsons, editorial-director of the Gas-Age-Record, emphasized this fact so thoroughly and with so much conclusive evidence that nobody was unconvinced. Nothing, said Mr. Parsons, is of greater importance to the national prosperity of the country than a correct solution to the coal problem.

History conveniently divides itself into certain easily distinguished periods which we call ages. We refer, for instance, to the stone age and to the bronze age and, today, many of us are inclined to refer to the present era as the steel age. Judging, however, from the reckless manner in which we are drawing upon our natural mineral resources, when we consider the wasteful methods employed in the mining, the transportation and the utilization of these resources, it will be obvious that this is, first of all, not the age of steel but the age of ivory domes. As time goes on, it will be made increasingly evident to future students of history that the upper, knob-shaped appendages of those living in the present age were made absolutely and entirely of solid bone.

Facts Regarding Our Use of Minerals

Our heedless use of mineral resources is a matter that should concern everybody. Mineral resources, unlike farm products, can never be replaced. While it is sufficiently serious from an economic standpoint to waste agricultural products, they, at least, can be duplicated from time to time. But with minerals, there can be no duplication, and once they are destroyed they are lost to us forever; and the end of some of our mineral resources is nearer than many of us imagine.

In the case of iron, if our present rate of consumption continues, all of our high grade deposits of this mineral will be exhausted at an early date. Copper, also, is rapidly being exhausted, and as to our lead resources, it is sufficient to state that we have mined more lead in the last 15 yr. than in the entire two centuries before. More coal has been mined in the past 13 yr. than in the entire preceding century.

The oil situation is even more alarming. At the present time we are witnessing a period of consumption over production. We have exhausted more petroleum reserves since the war began, that is, since 1914, than in all preceding history. According to the most eminent geologists, the quantity of oil still remaining in the ground in the United States is some 9 billion barrels, just enough, at the present rate of consumption, to last us 20 yr. This estimate, of course, does not take into account possible increased rates of consumption which will reduce even this insignificant period of time.

The importance of our mineral resources to modern civilization cannot be overestimated. It may be said that the real advance of man began when he discovered the use of stone implements and tools. They gave him a new degree of freedom and with them he found he could accomplish things which he had not been able to do before. As time went on he began to use copper, and again, he advanced towards a higher degree of civilization.

Today our high state of civilization can be attributed directly to the use of metals. Practically all of the

present-day comforts of civilization are brought about through the use of metals. Without them, we would have no modern skyscraper, no machinery, no electricity, no rapid means of transportation or communication; we would not be able to construct water and sewage systems, and as a consequence our cities would become foul and unfit for the habitation of people. The inhabitants would be compelled to seek the country; civilization would decline.

Yet, mining, the most important and most vital industry in the United States, is handled by one small bureau in Washington. The mining industry is the bedrock upon which the business of the nation is founded. We have a Navy Department and a War Department, yet if it were not for the mineral products with which the Bureau of Mines has to do, both the War and Navy departments would be of as much protection as a fleet of New England fishing schooners.

But, to return to the principal topic of this paper, what about coal? How are we to get an adequate supply of good coal the year around? Where is this coal to come from? Of course, there are many who find comfort in the thought that we have mined but two per cent of our coal resources. We can do better, however, in keeping before us the fact that one-third of the easily available coal has been exhausted. Some of the finest coal beds in Pennsylvania and West Virginia, from which we get our high volatile coals, will be exhausted within the present or next generation.

Our coal consumption in the United States at present is about 6 T. per capita per annum. In Europe the per capita consumption per annum is less than one ton—in Russia it is 0.018 T. Not only is our per capita consumption increasing, but our population also is increasing. If the present rate of growth continues, in four centuries the population of the United States will be greater than the population of the world is today. And, after all, four centuries is a short span in history. We shall do well to ask ourselves, where is the coal to come from to supply the needs of those who live three, four or five generations hence?

Coal Strikes

The immediate problem connected with the coal industry is to settle once and for all the matter of coal strikes. Coal strikes and famines are undermining the very foundations upon which the prosperity of the nation is founded. This year's coal strike will cost the country one billion two hundred millions of dollars. This vast loss equals and entirely offsets the amount of wealth added to the nation's store by the agricultural industry.

Now, nobody can deny the miner the right to quit work if he is not satisfied with conditions but when a comparatively small number of coal miners disagree with a still smaller number of mine operators and the resulting clash disrupts the entire industrial machinery of the nation and jeopardizes the public's welfare—when these things occur and recur with increasing frequency, then, it is time that something be done about the matter.

During the past 20 yr. these coal strikes have cost us untold millions of dollars and have brought ill health and injury to the inhabitants of our densely populated communities by suspension of smoke ordinances and the consequent burning of poor coals. The weight of the air inhaled in 24 hr. by the average person is approximately six times the weight of all the food he consumes in that period of time. In view of this fact, should it appear strange, then, that the health of people living in cities with smoke laden atmospheres should be affected? But smoke also destroys millions of dollars worth of property by corrosion to say nothing of the increased laundry bill directly attributable to deposits of soot on our linens and clothes. The cost of smoke in Chicago alone is $18,000,000 per year, and in New York where, for the first time in years the ordinance compelling the use of anthracite coal has been lifted because of the scarcity of hard coals, the cost will be even greater.

Obvious as these facts are, we permit them to continue. As a nation we are 90 per cent motion and 10 per cent accomplishment. If we expect to put an end to coal strikes which continually block the prosperity of the nation, we will have to have more concerted action and less talk.

Now, that all sounds very well, you say; but how can we prevent strikes? Is it possible to put an end to them? Towards this end the author of this paper proposes the following plan:

First, let there be established in Washington a department which we will call a Bureau of Coal Economics. Among other things it would be the duty of this bureau to keep an accurate account of all coal produced and consumed, and to watch carefully the reserve stocks.

Next, it will be necessary to define, by law, what constitutes a fuel emergency. In other words, what minimum value can we allow our reserve coal supply to reach before it will become necessary to take emergency measures?

Third, we should put through legislation by means of which we could effect compulsory arbitration, and provide proper means for enforcing such legislation.

The operation of this plan in case of a coal strike would be somewhat as follows: From day to day, as the strike progressed, the Bureau of Coal Economics would carefully keep track of the reserve coal stocks on hand. Suppose that a fuel emergency had been defined as being, say, 30,000,000 T., or approximately a 30 days' supply. As soon, therefore, as the nation's reserve stocks approached the 30-day value, the Bureau of Coal Economics would say to both miners and operators, "Your time is up. You have disagreed and in the three or four weeks that you have been idle you have not been able to settle the dispute between you, and now that the welfare of the nation becomes endangered, we shall have to ask you to step out and settle your dispute elsewhere. If you do not wish to continue at your customary work, you may seek employment elsewhere. We cannot, however, allow you further to block the interests of the public or the prosperity of the nation."

Only the government could carry this program through successfully; it alone has the required moral support of the public and the necessary financial backing. The miners cannot do it and neither can the operators. It is safe to say, however, that it would not be necessary to resort to this means more than two or three times before all parties concerned would see the futility

of trying to force their demands by jeopardizing the public welfare.

* * * *

A word concerning the future. It is said that only death and eternity are certain, but in the author's estimation, nothing is more certain than the coming of a gas age. The citizens of the future will probably regard our methods of handling and burning fuel in about the same light that we regard methods of our ancestors four or five generations back.

There is nothing in this wide world that will burn except gas. It may be assumed that when we burn coal or wood in our furnaces it is the solid fuel that burns. This, however, as every engineer well knows, is not so; the only thing that actually burns is the volatile gases which are driven off the fuel by the high temperature of combustion.

Since it is only the gases we burn, why then do we spend millions of dollars carrying thousands of tons of incombustible matter to our cities in the form of ash in coal? Why not transport only the gases?

Gas will be the fuel of the future. Instead of being carried to our cities as it is now, all the coal will be delivered to carbonizing plants near the mines where the volatile gases will be distilled off, and the valuable by-products recovered. Instead of having a thousand separate fires as at present, we will then have but one. Gas will be supplied from enormous gas plants to the cities and towns through long underground pipe lines.

Gas is an ideal fuel. It is smokeless, clean, easily controlled and is ready for instant use at all times. As to the practicability of transporting this fuel over long distances, we need only refer to the natural gas industry where for years gas has been carried through pipe lines hundreds of miles long. The feasibility of using pipe lines as a means of carrying fuel is further exemplified in the oil industry where oil is pumped through pipe lines extending from the oil fields in Oklahoma and Texas to the refineries in Bayonne, N. J., across the river from New York City.

The next ten years will witness greater progress towards fuel conservation than ever before. Hydro-electric sites should be developed to their fullest extent, as every horsepower of water developed means an annual saving of ten tons of coal. If the 5,400,000 hp. available in the St. Lawrence River alone were developed, it would mean an annual saving of 54 million tons of coal and would release 70,000 miners for other lines of work. Every horsepower of hydraulic energy developed, furthermore, releases $100 worth of coal-carrying equipment.

It is true, there may exist other possible sources of power which at present cannot be utilized. The ultimate solution of the power problem may lie in harnessing a portion of the solar energy reaching the earth or in the successful utilization of inter-atomic energy. Whatever the possibilities of these sources of energy may be, the end of our fuel resources is too close at hand to allow of these possible sources of energy being developed in time to rescue us. In the meantime, let us economize and utilize the resources still available to the best possible advantage.

Commercial Value of Exhaust Steam---II*

A Slight Sacrifice in the Efficiency of the Engine Makes Possible Greater Increase in Overall Efficiency. By Fred William Bosch

IN A NUMBER of cases exhaust steam is not used because its temperature is below that required for some process of heating or cooking, but the introduction of superheated steam has found its way into the exhaust steam field and eliminated this barrier.

For instance: if a temperature of 300 deg. F. is required and supplied by live steam at 52 lb. gage pressure, whereas exhaust steam at 5 lb. pressure or 228 deg. F. is available, it is only necessary to raise its total heat 33 units, from 1156 to 1189 B.t.u. Comparing this with furnishing live steam at 52 lb. pressure, having a total heat value of 1179 B.t.u. shows that less than 3 per cent of the heat energy is supplied in the former case, or a saving in coal of 97 per cent in favor of superheating the exhaust steam.

In many cases, it will be found convenient to return the exhaust steam to the main boiler for re-heating, but if this is not practical it will be found very economical to install a special boiler for this purpose. In either case, difficulties are not encountered, such as in high pressure superheating, as the temperatures required are, in general, much lower.

Exhaust steam cannot be successfully used in the manufacture of water gas, but excellent results are said to have been obtained by superheating the exhaust steam to a temperature of 450 deg. F. This is just one of the various uses of exhaust steam made possible by superheating, and it will undoubtedly rob live steam of many of its present uses.

Effect of Back Pressure on Engine Economy

With a reasonable amount of back pressure on an engine the effect is not so serious as generally believed or supposed. Naturally, if the back pressure is increased and other conditions unchanged, the power developed by the engine will be reduced, but this can be overcome either by increasing the length of the cutoff, thereby requiring a greater amount of steam, or by increasing the initial steam pressure, or both.

The most advisable method depends upon operating conditions. If there is a demand for the increased exhaust steam, it is better to increase the cutoff; but if the extra exhaust steam cannot be used, it is more economical to increase the initial steam pressure.

An example will readily explain these points:

Take a non-condensing engine, operating at 115 lb. abs. initial pressure, 15 lb. (back) absolute exhaust pressure, and one-quarter cutoff at full load, where it is desired to use the exhaust steam for heating purposes at 20 lb. back pressure.

Required to find:

1. The reduction in power developed by the engine

This article, the first installment of which appeared in the Oct. 15 issue, is an enlargement of another article the author of which is A. Langstaff Johnston, Jr., Vice-President Off. 'N' On Chain Corp., Buffalo, N. Y.

due to the increased back pressure. The initial pressure remaining the same.

The output of the engine under these conditions is proportional to the mean effective pressure in the two cases, which is obtained from the familiar equation:

$$Pm = p' \times \frac{1 \text{ plus hyp. log. } R}{R}$$

in which

Pm = absolute mean pressure;
p′ = absolute initial pressure;
R = ratio of expansion.

For convenience, the curve, Fig. 3, derived from this equation, is used.

At one-quarter cutoff the ratio of absolute mean to absolute initial pressure is 0.596 (read from curve) and, as the initial pressure is 115 lb. absolute, the theoretic mean is 115 × 0.596 or 68.54 lb. absolute. By increasing the back pressure 5 lb. the initial pressure and cutoff

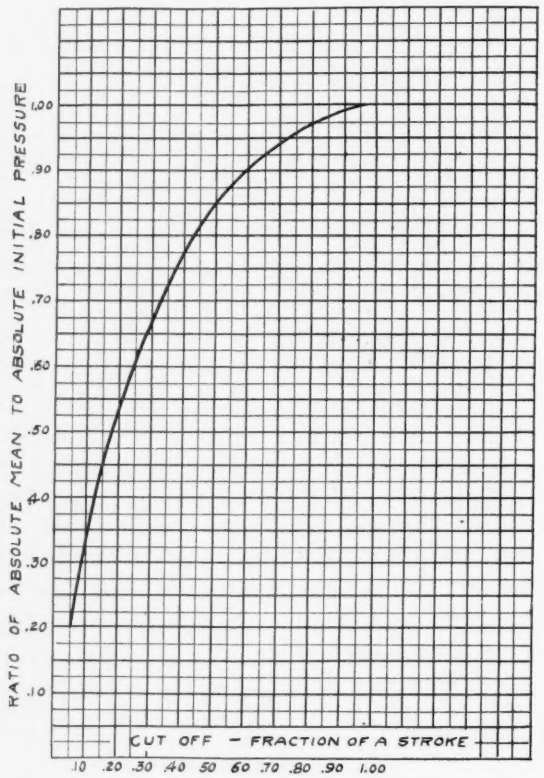


FIG. 3. VARIATION OF RATIO OF MEAN TO INITIAL PRESSURE WITH CUTOFF

remaining the same, the mean pressure becomes 68.54 — 5 or 63.54 lb. absolute; and as the output of the engine is proportional to the mean pressure, the reduction in power will be (68.54 — 63.54) × 100 ÷ 86.54 or 7.3 per cent.

Thus, by increasing the back pressure on the engine 5 lb., the output of the engine is decreased 7.3 per cent.

2. To find the increase in steam consumption due to increasing the back pressure 5 lb., the initial pressure and power developed remaining the same.

For the engine to do the same amount of work under these condititons, the same mean pressure must exist; therefore, a greater amount of steam has to be supplied by increasing the cutoff, and the problem resolves itself into finding the cutoff under the new condition.

With an absolute mean pressure of 68.54 lb. and an increased back pressure of 5 lb., the mean pressure for the engine to do the same work becomes 68.54 + 5 or 73.54 lb., and the ratio of absolute mean to absolute initial pressure, under the new condition, is 73.54 ÷ 115 or 0.64; and this ratio, from the curve, Fig. 3, gives a cutoff of 0.28.

As the steam consumption of an engine is proportional to the cutoff the resulting increase in steam consumption becomes (0.28 — 0.25) × 100 ÷ 0.25 or 12 per cent.

3. To find the necessary increase in initial pressure due to a 5 lb. increase in back pressure, the cutoff and power output remaining the same.

At one-quarter cutoff the ratio of absolute mean to absolute initial pressure is 0.596, and as above, the absolute mean pressure is 73.54 at 5 lb. back pressure; therefore, the initial pressure becomes 73.54 ÷ 0.596, or 123.4 lb. absolute, or an increase in pressure of 8.4 lb. This increase in pressure also causes a slight increase in the steam consumption due to the increase in the steam density.

The density of steam at 115 lb. absolute is 0.2577 lb. per cu. ft., and at 123.4 lb. abs. it is 0.2756 lb. per cu. ft. As the point of cutoff is assumed to be the same in both cases, the same volume of steam will be supplied, but in the latter case 0.2756 — 0.2577 or 0.0179 lb. per cu. ft., or 6.9 per cent more in weight is required.

One pound of steam at 115 lb. abs. contains 1188.8 B.t.u.; hence, each pound of steam raised to the higher pressure requires 1.2 B.t.u. more per pound of steam; or 0.1 of 1 per cent. Therefore under the third condition, 6.9 + 0.1 or 7 per cent more heat, and consequently that much more coal will be required.

Summarizing the above, we have, by increasing the back pressure 5 lb., the choice of three effects:

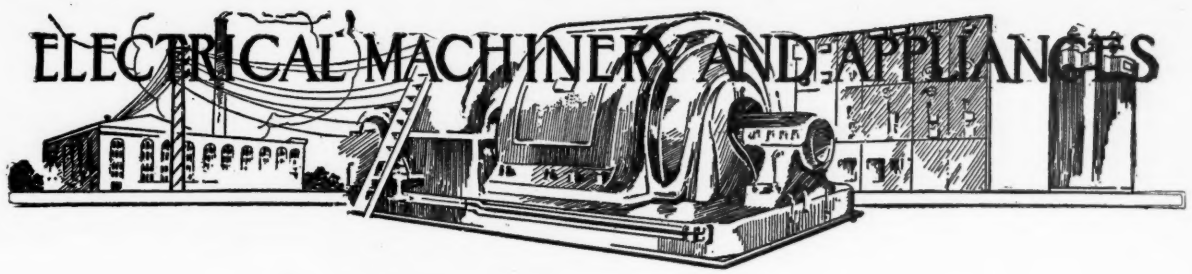
1. Maintaining the same initial pressure and steam consumption with a 7.3 per cent loss in power output of the engine.

2. Maintaining the same initial pressure and power output of the engine by increasing the steam-coal-consumption 12 per cent.

3. Maintaining the same power output by increasing the initial pressure 8.4 lb. or coal consumption 7 per cent.

These conditions will, of course, vary somewhat in actual practice due to the type and condition of the engine used, but the comparison conclusively shows the advisability of sacrificing a small efficiency in the operation of the engine to gain the many-fold increased efficiency of the plant as a whole.

From these facts it is hard to conceive why a factory or building of any size, requiring heat and power, does not take advantage of the wonderful overall-efficiency offered by the simple steam engine, more particularly the uniflow steam engine, and if our business men will allow themselves to be educated regarding their heat and power department as they have regarding their other departments, the old familiar steam engine will more than maintain its position in the industrial field, not so much as a prime mover but as a "by-product" power producer.



Polyphase Wattmeter Connections---II

DISCUSSING VARIOUS POSSIBLE COMBINATIONS AND METHODS OF CHECKING CORRECTIONS. BY L. P. STAUBITZ

WATTMETERS INTENDED for use with current and potential transformers usually have each element connected to separate binding posts. A polyphase meter will thus have eight posts in all. With this type of watthour meter on loads having a power factor less than unity and greater than 0.5, we can, by using both elements, obtain twenty combinations of connections which will give forward rotation of the disks. Only four of these combinations, however, will give accurate registration. It is, therefore, easy to understand how it is possible to have difficulty with the wattmeter connections if great care is not taken in the wiring of the meter. It is also true that forward rotation of the disk is not necessarily a proof of the meter being correctly wired.

In Fig. 2 is shown the correct wiring of a polyphase watthour meter supplied from current transformers only. It will be seen that the A current element has AB pressure on its corresponding pressure coil and the C current element has BC pressure on its pressure coil.

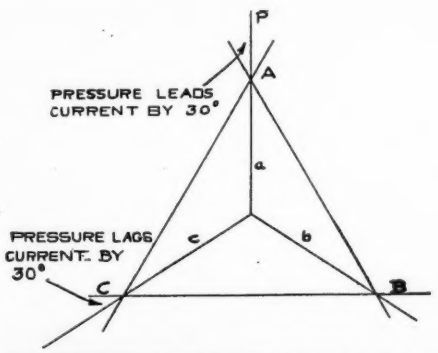


FIG. 1. RELATIONSHIP OF CURRENT AND PRESSURE OF EACH ELEMENT OF A CORRECTLY WIRED WATTHOUR METER AT UNITY POWER FACTOR

From the vector diagram, it is seen that the AB pressure leads the A current by 30 deg. in phase at unity power factor, and the BC pressure of the C current coil lags its current by 30 deg. It is absolutely essential to maintain this relation of pressure and current in the two elements of the wattmeter at unity power factor as the torque produced by the leading pressure on one element is compensated for by the lagging pressure of the other. This balance holds true for all power factors as the angle on each element changes equally. If, however, the pressure on each element was leading or lagging, the meter would not register properly. The vector relations are shown in Fig. 1.

Now let us consider the instantaneous flow through the meter elements of Fig. 2. Consider the case when the power flow is from A to B phase. The current enters the A phase current transformer on the marked primary and the secondary current leaves over the marked secondary lead. The secondary current flows from the

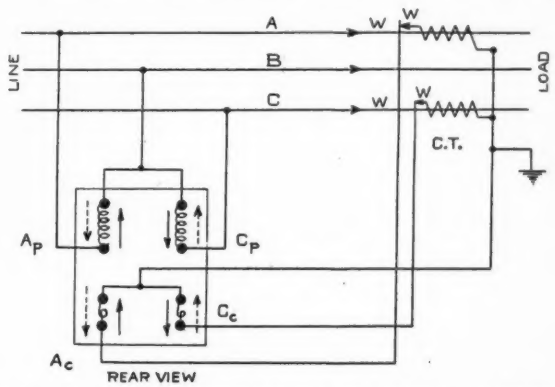


FIG. 2. DIAGRAM SHOWING WIRING OF A WATTHOUR METER SUPPLIED FROM CURRENT TRANSFORMERS

marked lead, through the current element of the meter from the lower binding post to the upper one, then back to the A phase current transformer over the common wire. The pressure flow is from the A to B phase and is from the lower to upper binding posts of the pressure coil. The flow in the pressure and current coils is in the same direction. With the power flow from B to C phase, the following conditions exist: the pressure is from the common pressure wire B through the pressure element down to the C wire and back to C phase power wire. The current flow is out on B power wire to load and back through C current transformer. The secondary current at this instant is out on the unmarked secondary lead to the C current transformer through the C current meter from top to bottom post and back on the C current wire to the C current transformer. To complete the cycle, we must consider the instantaneous flow from C to A. The pressure flow is from the lower C element binding post up to the common tie wire down through the A pressure coil to the A wire and out. The current flow is out on C power wire and the secondary current is out on the marked lead through the current element from top to bottom and back on the common wire. The power

current flow in returning to A phase passes through the current transformer from the unmarked to the marked lead. The A phase secondary current passes from the common wire through the current element from the top to bottom and back to the current transformer on the A current wire.

It is therefore obvious that the instantaneous flow in the pressure and the current coil of one element at

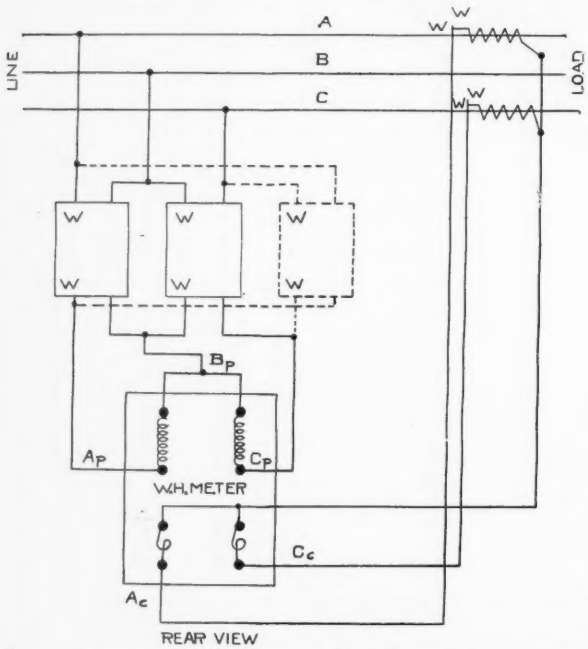


FIG. 3. METHOD OF CONNECTING WATTHOUR METER AND INSTRUMENT TRANSFORMERS

any point in the foregoing cycle is in the same direction. This is necessary with this type of meter as found from the previously described test.

It may be said that the reason that two wattmeters can measure the total power to a three-phase, three-wire

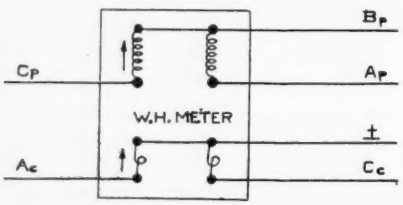


FIG. 4. IMPROPER CONNECTIONS OF WATTHOUR METER

system is due to the fact that at two instances the path of the pressure and current flow is through only one element while for the third instant the pressure flow is through two coils in series and the current flow is also through the two current coils, but not in series.

The third condition is therefore equivalent to having half pressure on each coil with full current, thus measuring the total three-phase power. This statement must not be taken to mean that at any instant a voltmeter across a pressure coil will read half the normal voltage, for it will not. This simply refers to the path of flow and illustrates how two meters may record three-phase power.

The substitution of potential transformers having the same class of polarity as the current transformers shown in Fig 2 does not change the foregoing consideration. These are shown in Fig. 3.

It is also correct to wire the meter with the lower pressure binding posts connected to B phase, provided the lower binding posts of the current elements are made common and connected to the return wire. The relationship of the current and pressure flows will not be changed by this wiring.

When wiring up wattmeters during the construction period of a station, it is often customary to wait until the feeder is operating to check up the wattmeter. The usual procedure in testing out the meter is to disconnect

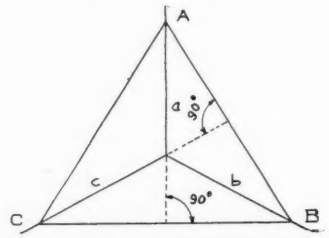


FIG. 5. VECTOR DIAGRAM OF CONNECTIONS SHOWN IN FIG. 4 AT UNITY POWER FACTOR

one pressure coil at a time and with a power factor above 0.50 forward rotation of the disk should result. This method is fairly accurate provided the power factor of the system is positively known. The difficulties which may be encountered in checking up the meter by this method will be shown by the numerous combination of meters found in practice.

Checking Connections

THE SAFEST and most reliable method of checking this connection is actually to ring out the wiring, having everything disconnected.

In Fig. 4 is shown a condition which may often occur from wiring a meter without checking the wires. This combination will result in the meter standing still at all loads if the current in the three phases is equally balanced. The vector diagram is shown in Fig. 5. It will be seen that the A current element of the meter has BC

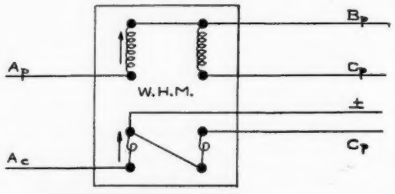


FIG. 6. METER INCORRECTLY WIRED. METER ROTATES IN RIGHT DIRECTION

pressure on its corresponding pressure coil. From inspection of the vector diagram, it is seen that the current and pressure are at 90 deg. to each other. This is also true of the relationship of the C element which has AB pressure on its coil. The usual way of obtaining forward rotation of the disk under this condition is to reverse either the pressure or current coil of one element of the meter. This method of procedure will not, however, result in accurate registration. The proper way to correct this

condition is to interchange the pressures to their proper coils, which brings it back to conditions shown in Fig. 2. Where this transfer is made on an indicating wattmeter having external reactance in series with its pressure coils this change should be made ahead of the reactors.

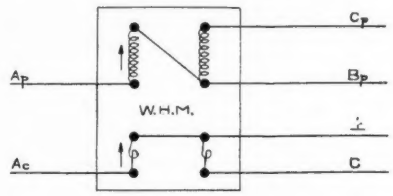


FIG. 7. METER INCORRECTLY WIRED. METER ROTATES FORWARD. METER POLARITY SHOWN BY ARROWS

The reactors are designed and checked for a particular element of the meter and should not be changed.

Another error found occasionally is shown in Fig. 6. The pressure and current are on the proper elements, but one element is reversed. Forward rotation will result from this connection if the proper element is reversed, but its registration will be that of the reactive

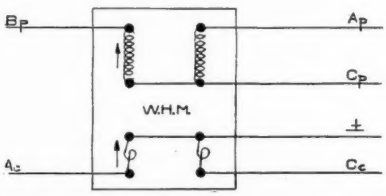


FIG. 8. METER WILL ROTATE IN CORRECT DIRECTION BUT WILL NOT REGISTER ACCURATELY

kv.a. of the circuit instead of the true power. To correct this with a meter having a polarity as shown by the arrows, it would be necessary to put the wire marked C on the lower current binding post and bring the common wire to the top binding post. The connection depicted in Fig. 7 is the same as that shown in Fig. 6 except that the reversal has been made on the pressure element. This connection is also wrong. In Fig. 8 is

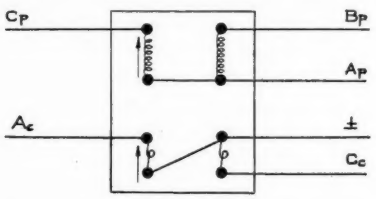


FIG. 9. METER INCORRECTLY WIRED

shown an unusual connection which will give forward rotation of the disk. This is sometimes met with in practice and it is needless to say that the meter will not register properly. To correct this, the pressure wires must be changed to conform to Fig. 2.

In Fig. 9 is shown another combination that will give forward rotation of the disk and must be changed to conform to Fig. 2 in order to register correctly.

It was previously stated that the method of connecting the potential transformers shown in Fig 3 (October 15 issue) would be explained later in the article. This connection is shown in Fig. 10 and includes a meter of the same make and a meter requiring that the instantaneous flow in the meter from binding post to binding post

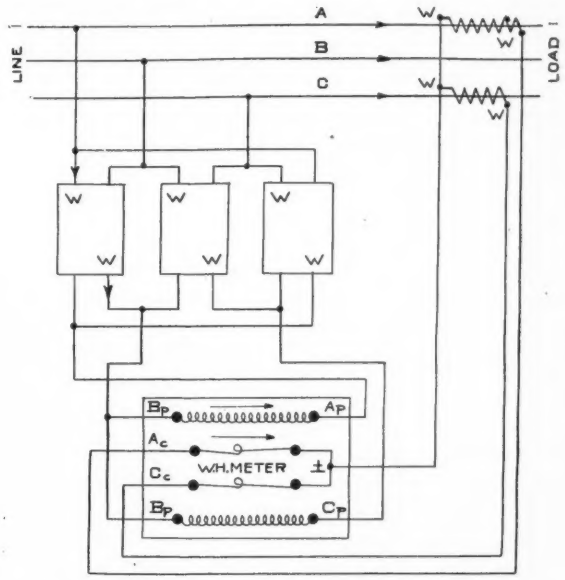


FIG. 10. CONNECTIONS OF A WATTHOUR METER, CORRECTLY WIRED

be in the same direction. It will be seen that the common pressure tie and current tie are on opposite sides of the meter. Considering the power flow from A to B phases, the flow into the primary of the left-hand trans-

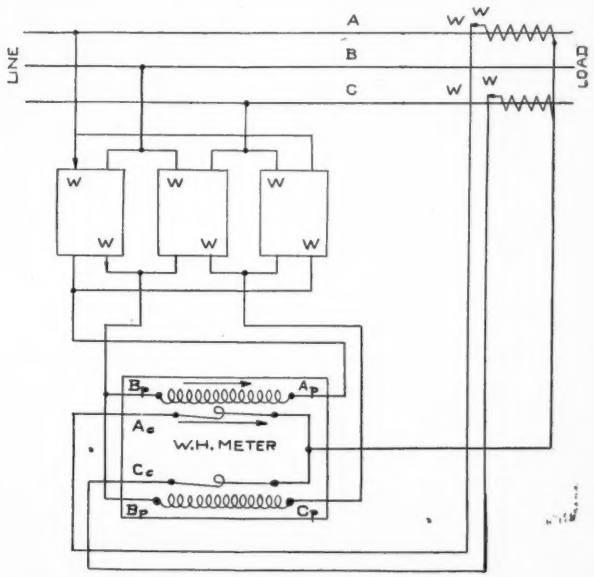


FIG. 11. SHOWING COMBINATION OF POTENTIAL AND CURRENT TRANSFORMERS

formers is on the left-hand lead and out on the right-hand secondary lead down to the common tie on the meter. From the meter the flow is back to the left-hand potential transformer. The flow in the current coils is

in the same direction as that of the pressure coil and this is correct for this type of meter.

Instrument Transformer Combinations

In practice it is often necessary to operate a meter from potential and current transformers having different polarities.

In Fig. 11 is shown the connection for a wattmeter that is supplied by a bank of transformers having opposite polarity while the current transformers have polarities on the same side. It will be noted that the common tie on the current transformers is on the load side. The common ties to the pressure and current binding posts on the meter are on opposites sides.

Figure 12 shows a condition with potential transformers having polarities on the same side and current transformers with opposite polarities. It will be noted that the tie on the current transformers is on the line side while the pressure and current ties on the meter are on the same side.

Field Checks

The best way to check wattmeter connections in the field is actually to ring out the pressure and current

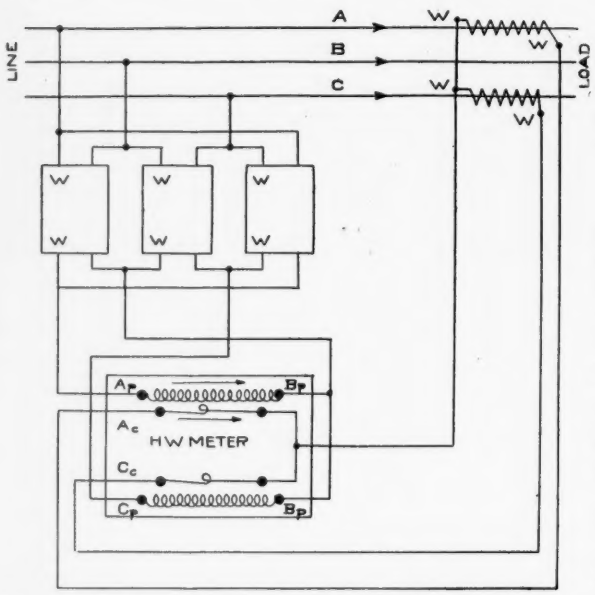


FIG. 12. CONNECTIONS OF WATTHOUR METER WITH INSTRUMENT TRANSFORMER OF DIFFERENT POLARITIES

wires, making a diagram as this is done. If it is known that the wire connecting to the two common pressure binding posts is of the proper phase, then interchanging the other two pressure leads will cause the meter to stop, if the three-phase load is balanced. This, then, means that the original wiring is correct. This method requires knowledge of one pressure wire and therefore emphasizes the fact that the best check is the following through of each wire. After making a check, it should be analyzed to see that the directions of the various currents are as outlined earlier in the article.

Summary

One of the first things to determine, if unknown, is the polarity of one element of the meter when operating single phase. From this it is possible to figure out any connection to give correct relationship of pressure and current.

A polyphase meter when measuring three-phase power must have one element in which the current leads the pressure, and one in which the current lags the pressure, the angle at unity power factor being 30 deg. The polarities of the instrument transformers are known from the make.

Having this information, the proper connections for any combination of wattmeter and instrument transformers may be readily determined.

Turning Down the Commutator

By J. B. Dillon

IT WAS an old armature; the commutator had been turned down many times. The machine worked with four brushes, two in the upper and two in the lower brush holders, yet the brushes had been allowed to work in the same position as regards the commutator, a deep rut resulting in the commutator, the generator sparking badly, and the service generally unsatisfactory.

An investigation showed that it would stand one more turning down if carefully done and the expert on the ground said to the repairman: "Tom, I'm afraid it will hardly stand to be turned down, but to work it, it's got to be done. Now don't trim it a fraction more than is absolutely necessary."

"By Joe, she is thin, but we can take care of that."

There was a shoulder on the commutator, about ¼ in. wide and fully as deep, on the inner end. This shoulder came about by the previous turners not trimming clear to where the segments turn upward to receive the coil ends.

While the armature was being turned down, the expert said to the regular attendant:

"You should move the position of your brushes on the commutator, frequently, so as to get as near uniform wear as is possible. This will prevent the wearing in of deep ruts such as you saw on that commutator."

"That's a splendid idea, but I never thought of that. I'll try it on that armature Tom is truing up."

When the armature was returned, the commutator looked awful pretty, but the expert threw up his hands in horror: "Good Lord, man, why did you cut away that shoulder? Don't you know that re-enforced the strength of those segments where the pull is the greatest? And I warned you not to cut it too thin."

"Sorry, but to tell you the truth I intended to supervise that job, but being met at the office by some people who wanted to talk business, one of the men, knowing it was a 'hurry up' job, beat me to it, still I think she is all right for sometime to come."

The expert shook his head, replacing the armature and the machine started off gloriously.

It was about one-half hour later a loud noise was heard and rushing in the direction of the generator it was seen that the commutator was torn to pieces, having given way at the bend of the segments at inner end where the shoulder had been cut away. Some of the segments were thrown out on the floor, while others were wedged into the armature coils like darning needles in a

ball of yarn, the whole thing resembling driftwood in a mud bank.

The lesson to be learned here is: Vary the position where your brushes rest on the commutator, that is rocking them from the outer to the inner end frequently and when turning down a commutator do not trim it clear to the inner end, but leave a small shoulder to maintain the strength of the segments.

Long Time Element Relays for Large Apparatus

OIL IMMERSED THERMAL RELAY HAS CHARACTERISTIC SIMILAR TO THAT OF APPARATUS IT PROTECTS. BY H. D. HINELINE* AND B. H. SMITH*

LARGE ELECTRICAL apparatus, such as rotary converters, large generators, railway motors, etc., requires a considerable length of time to reach temperature equilibrium. This type of apparatus can take a very considerable overload and carry it for a considerable length of time, if it is cold or nearly cold at the beginning of the overload.

Because of this fact, it is desirable that a relay operating on a thermal principle be provided which will have temperature characteristics approximating those of the apparatus to be protected, in order to permit full utilization of its overload capacity. For instance, in railway sub-station service, a rotary, which has been out of service for a time, may be started up to carry a peak load, and it is possible to carry an overload greater than its rated capacity for perhaps one or two hours. This would enable the sub-station to take care of large peak loads easily, provided a protective relay would prevent such an excess load being carried long enough to injure the apparatus.

The requirements then are for a thermal relay having temperature characteristics following closely that of the large apparatus with which it is to be connected. Such a relay has been recently developed under the name of "Oil Immersed Thermal Relay."

This relay, which is shown in Fig. 1, uses thermostatic metal as a heat sensitive element is immersed in oil and is contained in a substantial brass case, so that the thermal capacity of the relay approximates that of large electrical apparatus.

The heat sensitive element carries the current and the oil serves as a means of rapidly distributing the heat generated. The element also carries a graduated drum visible through a window in the case, thus indicating the temperature condition of the relay and, therefore, the temperature condition of the apparatus to which it is connected.

The contact mechanism is arranged to make a steady positive contact, which is not disturbed by a considerable amount of vibration, if such is present. This is accomplished by means of a magnetic seal, which also serves to hold the contacts closed, and with suitable control circuits will hold the equipment out of service until the reduction in current through the relay has permitted it to cool off to such a point that the magnetic seal is broken. The contacts then open and the relay is ready to function again.

The relay may be supplied with four different contact arrangements. They may be normally opened and closed by excess temperature, or they may be normally closed and opened by excess temperature. The contacts may be arranged to remain closed for a considerable length of time after having operated or they may be arranged to open after a few seconds or a minute after operating.

The time which the relay requires to operate with a given overload depends upon its thermal capacity, and since a large share of the heat capacity is the brass case of the relay element, it is possible to get a considerable adjustment by changing the thickness of the case. Some variation is also possible in the amount of contained oil. These features are evident from inspection of Fig. 2.

The relay is designed to be operated from a current transformer. Since the average current transformer

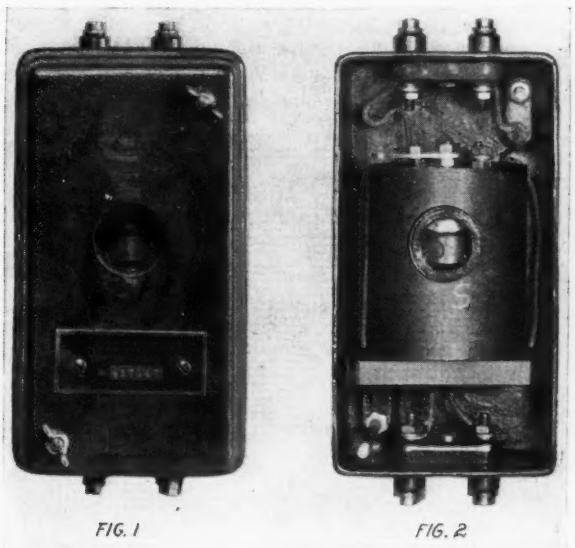


FIG. 1. OIL IMMERSED THERMAL RELAY WITH COVER
FIG. 2. RELAY WITH COVER REMOVED

will, under short circuit conditions, deliver several hundred amperes from its secondary, protection of the relay against short circuit is necessary. This is obtained by a small saturating transformer connected in the relay case which is arranged to give a good ratio of transformation even at considerable overloads; but with large currents under short circuit conditions, the current delivered to the relay element will not exceed a safe value. The relay is also designed to operate on direct current from a shunt.

The curves shown in Fig. 3 give the characteristics of the relay. It will be noted that a considerable number of hours are required to obtain final temperature equilibrium and thus, with the heavy case relay, the curves show that 3 hr. and 15 min. are required to reach the 90 per cent point. This corresponds to the time required for a great proportion of medium and large size electrical equipment to reach a similar condition of final temperature equilibrium.

*Engineers with the Westinghouse Electric & Manufacturing Co.

In calculating the time delay under any given conditions, it should be noted that the condition of the relay at a given time corresponds to the mean effective energy input over a period of a number of hours preceding. If then an overload occurs, the time which the relay will require to operate can be figured by noting the dial reading and finding that point on the curve which corresponds to the new load condition and following that curve up to a point corresponding to the contact setting of the relay. The horizontal distance between these points then will give the time which will permit the machine to carry the overload.

It should be emphasized that if a machine has already been loaded to its rated capacity for a number of hours, so that the temperature equilibrium is practically reached, a small overload will cause the relay to close its contacts in a comparatively short time, frequently only a matter of a few minutes, so that when the statement is made that the relay has a time element of two hours, it does not mean that it will always permit an overload to be carried for such a length of time.

It is obvious then that since the relay follows the temperature of the protected apparatus closely, it can be depended upon to permit the machine to carry a substantial overload for some time, and if the overload is not removed, when the machine approaches a danger-

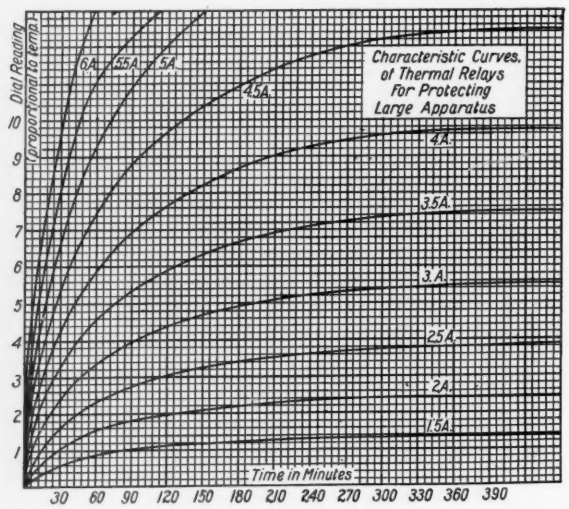


FIG. 3. CHARACTERISTIC CURVES OF THERMAL RELAYS

ous temperature, the relay will automatically close its contacts and shut down the apparatus.

The long time thermal relay is of particular value for such uses as automatic sub-stations where it serves not only for overload protection, but also for starting up an additional machine when the machines already in operation are not sufficient to carry the load. It does this on the basis of the thermal conditions in the running machines and thereby permits them to carry a substantial overload for a short time, if they are in a thermal condition to handle that overload. The relay is adapted also for use on electrical locomotives where it serves largely as slow responding ammeter. On locomotives it is not generally desirable to connect the relays to circuit breakers, but they may be connected to current limiting devices of some sort or to a signaling device for the engineer.

Another use of these relays is for the protection of large mill motors in the steel industry. Protection is furnished in conditions of extreme momentary overload where electro-magnetic devices, set high enough to allow the momentary peak loads, would be of no value against continued overload. The thermal relay, however, allows the machine to be worked at its full capacity.

Pumping Engine Efficiency

By Robert Grimshaw

AS SHOWING the influence of the financial factor as well as the load per cent, I show comparative annual figures, not new, but the latest I could get, and probably not yet surpassed of a Nordberg 800-hp. engine at two loads, in millions of British thermal units:

	Duty, Million B.t.u. 50	180
First Cost—		
Engine	$24,000	$148,000
Engine per hp.	30	185
Boilers and economizers	27,000	7,500
Engine and boilers	51,000	155,500
Interest and depreciation—		
Engine at 6 per cent	1,440	8,880
Boilers at 8 per cent	2,160	600
Total	3,600	9,480
Labor	6,022	10,220
Fuel—4000 hr.—		
$3 per ton	17,280	4,800
$4 per ton	23,040	6,400
$5 per ton	28,800	8,000
Fuel—6000 hr.—		
$3 per ton	25,920	7,200
$4 per ton	34,560	9,600
$5 per ton	43,200	12,000
Total Annual Cost 4000 hr. Coal		
$3 per ton	$26,902	$24,500
$4 per ton	32,662	25,100
$5 per ton	38,442	27,700
Total Annual Cost 6000 hr.		
$3 per ton	35,522	26,900
$4 per ton	44,182	29,300
$5 per ton	52,822	31,700

Taxes and insurance are not considered, as they vary with time, place and other conditions.

Nordberg pumping plants are on record as having a duty of 162,948,824 ft.-lb. per million B.t.u.

A comprehensive series of tests on the dewatering of washed coal sludge with vacuum filters has been made at the Central Experiment Station of the Bureau of Mines at Urbana, Ill. These tests led to the conclusion that where the sludge is clean enough to be of fuel value and the water supply is such that reclamation of the water is important, the use of filters is practicable. During a partial survey of coal washing practice in the Birmingham District of Alabama, especial attention was given by the Bureau of Mines to methods of drying in use. Data on the operation of centrifugal driers and on gravity drainage at one plant show the same resulting moisture reduction by centrifugal drying and by natural drainage in railroad cars for 24 hr.

Not According to Hoyle

IN WHICH JUGGLING A SHUNT FIELD SWITCH SAVES A LOT OF TROUBLE SHOOTING TIME. BY ROBERT HAMILTON

"BY GOLLY, I don't know why we have so much trouble convincing these manufacturers that we know what we want," exclaimed Watkins as he burst into my office with a letter in his hand; "just read this."

"What's up now?" I asked as I took the letter from him and read the following tale of woe:

Gentlemen:

We note in checking over the specifications for the direct current panel of your 100-kw. M. G. set, that you have specified a single-pole knife switch to be placed on the board and connected in the shunt field circuit.

As this is contrary to standard practice, we are calling it to your attention, thinking that an error has been made. You must realize, of course, that should one of your operators inadvertently open this switch under heavy load conditions, there would be quite a possibility of puncturing the field insulation because of the induced voltage.

Kindly advise us further in regard to this matter.

Very truly yours,

SALES ENGINEER.

"Well, what about it," I asked, "did somebody pull a bonehead play?"

"Not on your life," barked Watkins; "just because it's not quite according to Hoyle they think we are a bunch of boobs. But I suppose they have got to play safe," he continued, more pacifically.

As I hadn't been with the mining company very long, the ways and methods of the Lake Superior country engineers were still new to me so I was rather interested.

"What about this shunt field switch business?" I asked, "It does seem just a bit out of the ordinary."

Watkins took out an old pipe that had a most evil odor of stale tobacco, carbide and mine water and proceeded to fill it with Peerless before he answered:

"Well, that's a stunt the Old Man worked up for clearing trouble on underground trolley circuits. You see the direct current feeder down each shaft may have 30 or 40 trolley circuits tapped off it, one circuit for each level. At each level there is a box with a knife switch and a fuse block. If a trolley wire grounds for any reason or there is a bad locomotive, the fuse is supposed to blow and clear it.

"Supposed to blow is right," laughed Watkins, "for as a matter of fact about the first thing a miner does is to take a strand of bonding wire and make a real fuse that will let him pull a locomotive clear down until she stalls, lean a piece of drill steel against the trolley, or do anything else that may occur to him. I expect if you went down through the shaft you would find that every box was so equipped with this 'safety first' measure.

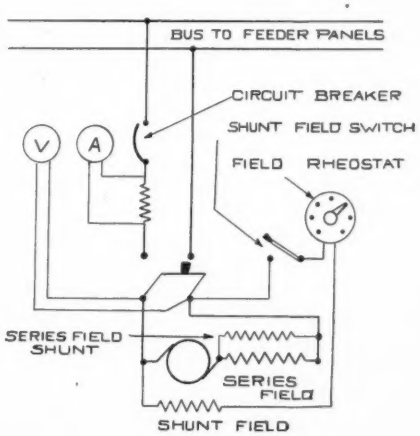
"As a result, if a level really does get in trouble the circuit breaker on the feeder will go out before the fuse has time to melt. That means a whole shaft will be out of commission where, as a matter of fact, the feeder is supposed to be cleared by the fuse at the level in trouble.

"Now that is a rather serious proposition, for it's a hard job to locate the level in trouble. It means sending a man down in the cage or skip to inspect every switch box and when a shaft is 4000 to 5000 ft. deep with levels every 100 ft. that would mean a lot of delay besides tying up equipment that is supposed to be used for other purposes.

"You would think," continued Watkins, "that the place to correct such trouble would be at the source; that is, see that the circuit fuses were of the proper rating and that the boxes were kept locked. Such a condition would be ideal; but unfortunately, like a lot of operating problems, the conditions can't be maintained on such an ideal basis."

"Continue," says I, "you have aroused a feeble spark of interest in my overwrought brain and besides this is my busy day."

"You see," stated Watkins, ignoring my subtle irony, "the old man figured that if he could keep the feeder



SHUNT FIELD OPENED BY KNIFE SWITCH ON PANEL AND SERIES FIELD IS SHUNTED TO CONTROL CURRENT FOR TROUBLE SHOOTING

circuit breaker in the power house from going out instantly, the time interval would be sufficient to melt the fuse on a grounded level circuit even if it took 200 or 300 amp. to do it.

"Naturally the heavy over compounding of the generator has a lot to do with the speed with which the circuit breaker goes out, for the increased current through the series field, with practically a short circuit on the line, means a very rapid building up of the amperage."

"What could be more simple, then, than to shut the series field at the generator terminal block and by cutting a single-pole switch in on the shunt field, control the excitation of the machine?

"If a level circuit should be grounded the feeder circuits to other shafts could be opened for a moment, the series field shunted and the shunt field switch opened. Then with the circuit breaker closed on the bad feeder, the shunt field switch could be closed. Naturally, the voltage would build up enough to cause current to flow through the short or ground. By opening and closing the shunt field switch, the current could be kept within

the circuit breaker and the fuse on the bad level would burn out in a jiffy."

"But," I exclaimed, "how about arcing when you open your field switch and isn't there any danger of puncturing the field insulation?"

"There is some arcing, of course," said Watkins, "but what of it? We do use a small carbon break switch now, but we formerly used just an ordinary knife switch. I suppose there is some induced voltage, but we have never had any trouble and we have used this method on a number of generators. It has saved us so much time and worry that it is well worth the loss of a field, which I think is a rather remote possibility. You understand, of course, that we pull the shunt field switch slowly."

"By heck, it's snowing again," I exclaimed, as I peered out the window across the line of shaft houses that faded away in the dwindling twilight and met the horizon of forest and sullen sky. "Did you ever see so much snow? Where does it all come from, I want to know? By Jove! The porch on Martin's house is buried nearly to the roof."

"Aw, wait till you've been here for a few years," broke in Watkins, "this is a light winter so far."

"Cut the 'worst in forty years' story you are about to tell," I exclaimed, "let's beat it for grub."

Some weeks later as I sat at my desk, trying to make the output of the power houses check against the totals of the various substation readings without having about 50 per cent left over, the telephone bell rang.

"No. 1 shaft pump cable shows a heavy ground on one phase,"—it was the foreman speaking.

"Have you located it?" I cut in.

"We have sectionalized every 1000 ft. and located it in a section between the 10th and 20th levels. We have inspected every foot of that section and there isn't a thing to be seen. What would you suggest doing?" he asked.

"There's only one thing to do," I answered, "locate the ground, cut the cable and put in a splicing junction box."

"Sure, tell me something I don't know," exclaimed the foreman sarcastically. "What I want to know is how to locate the ground. I suppose we could try our tele-fault outfit that we use on telephone cables, but we can't do that until Sunday because I can't hold up the pumps any longer. You think it over and let me know if you get any brilliant ideas," and the foreman hung up.

Now, a ground on a power cable is not particularly serious on an undergrounded system unless another phase becomes grounded on the same or another cable. Just the same, the sooner you clear your ground the better for it's a weak point in your system.

Taking out my trusty pipe and placing my feet carefully on the highly polished desk, I prepared to give myself up to ruminations which I felt might develop an inspiration.

Suddenly I thought about the scheme Watkins used to clear the trolley circuits. That might work in this case by using the armor as one conductor and the grounded wire as the other. If we could feed a couple of hundred amperes through the grounded spot, an inspection ought to locate the trouble. Enough smoke would be generated so that you could see the place for some distance.

It would be a simple matter to hook on to the direct current feeder at the top of the shaft so I thought the method worthy of a trial.

"Listen to me, old war horse," I said as the foreman came in my office the next morning, "you trot out a couple of men next Sunday and if we don't locate that ground inside of 15 min. then I'm willing to admit that as an engineer I would make a good street cleaner."

"How come? What's the dope?" inquired the foreman.

"You have your men," I explained, "cut in a jumper on the direct current feeder at the junction box at the top of the shaft. Fasten the positive wire to the grounded wire and the negative side to the cable armor. Have them call me up at No. 4 engine house, and then start on an inspection trip over the bad section."

On Sunday when the men called up that all was in readiness, I had put the shunt on the series as per Watkins' instructions. Then I threw in the feeder switch to No. 1 shaft and closed the shunt field switch. The current began to rise and when it got to 200 amp. I opened up the field switch. When the current dropped back, I closed it again and kept juggling it, keeping the amperage at about 200.

In about 10 min. the telephone rang. It was one of the boys calling from the 18th level. "Cut off the juice, we've located the place, she was smoking like a house afire."

"What did you find yesterday?" I asked the foreman when I saw him the next day.

"One of those ——— timbermen in nailing up a ladder drove a spike right through the cable, grounding one wire dead on the armor. The ladder set down so close on the cable that the boys couldn't see a thing when they inspected it. Don't it beat the devil!" he exclaimed disgustedly, as he took the last cigar I had.

The Wonder of Co-Operation

TWO BUSINESS men were discussing the lecture advertised for the evening. According to the poster, the speaker would talk of "The Spirit of Service."

"What do you think he will take for his theme, Charlie?"

"I believe I can best answer your question by quoting David Gibson: 'In modern business, the basis for success is service, and real service is, of necessity, based upon a genuine interest in the other fellow. Every transaction must be mutually profitable,—the buyer must be as well satisfied as the seller. This is the ideal and the practice of most business men.'"

"Well, in that case, then, it is merely a matter of co-operation?"

"Exactly; and believe me where there is co-operation in an office, in big or little business, factory or farm, all being timely, you will see the Spirit of Service."

Here we have a real meaning of co-operation, and it will be readily understood that without co-operation there can be no real service and as each man's worth is measured by the service he renders, a man must be considerate of others if he hopes to pass favor.

IN THE care of storage batteries, never add electrolyte to a cell after the gravity has been adjusted to the proper point, unless to replace actual loss by spilling.

Moisture Content of Air

HUMIDITY OF AIR USED FOR HEATING AND VENTILATION HAS AN IMPORTANT BEARING ON THE EFFECTIVENESS AND EFFICIENCY OF THE SYSTEM

IN the design and operation of a heating and ventilating system for any building, particularly one in which the health and comfort of human beings is to be considered, or in a factory building where the product handled requires certain quite definite weather conditions, one of the chief objects sought is the establishment of such conditions that heat will be removed from the body at a normal rate. Body heat is dissipated in three ways: by radiation to colder objects, by convection, and by evaporation of moisture from the skin. As relatively large amounts of heat are lost by convection, in a normal atmosphere, the temperature of the air and the amount of air movement are factors of importance.

Heat lost due to evaporation depends upon the relative humidity and the movement of the air. It is also dependent, of course, upon the amount of perspiration given off by the pores of the skin. This varies within quite wide limits in different individuals and also in the same individual under varying degrees of exertion. Comfortable conditions may exist, however, through a rather wide range of temperature and relative humidity, provided that the combination of the two is correct. The rate of air movement may also vary but within rather narrow limits. Practice has shown that comfortable conditions may exist anywhere from a temperature of 70 deg. F. and a relative humidity of 35 or 36 per cent to 65 deg. and 56 per cent. The relation between the two may be expressed by the simple equation $H = 316 - 4t$. Where R is the relative humidity and t, the temperature.

The object of supplying heat and ventilation to a building is, of course, to keep the occupants comfortable. Can this be accomplished better by a high temperature and low humidity or by a lower temperature with a higher humidity? Will there be any advantage as far as economy of fuel consumption is concerned, in using one combination rather than another? Suppose a pound of air at 30 deg. F. and 50 per cent humidity is suitably conditioned for comfortably heating a building. This air contains 12 grains of moisture. To obtain say 35 per cent humidity at 70 deg. 26 grains of water will have to be added. To evaporate the water will require $26 \div 7000 \times 970.4 = 3.6$ B.t.u., assuming that the specific heat of the vapor is 0.5, the heat required to raise the temperature of the vapor from 30 to 70 deg. will be $(12 + 26) \div 7000 \times 0.5 \times (70 - 30) = 0.11$ B.t.u., and that to heat the air of specific heat say 0.25 will be $1 \times 40 \times .25 = 10$ B.t.u. or a total of 13.71 B.t.u.

On the other hand, to obtain 56 per cent humidity at 65 deg. F. 39 grains of water will have to be added. To evaporate this water will require $39 \div 7000 \times 970.4 = 5.4$ B.t.u.; to superheat 51 grains to 65 deg. F. will require $51 \div 7000 \times 0.5 \times (65 - 30) = 0.127$ B.t.u. and to heat the air will require $1 \times (65 - 30) \times 0.25 = 8.75$ B.t.u. The total in this case is 14,277 B.t.u. as compared with 13.71 B.t.u. in the first case. Thus it would seem that it would be more economical to use a higher temperature with a lower relative humidity as the same ultimate effect is secured with less expenditure of heat. Heat transmission to an atmosphere of higher humidity and lower temperature might on the other hand be more efficient. This, however, is a question on which there is little if any data available.

Normal humidity of the outside air usually varies from about 40 to 80 per cent. When the temperature is low as it is during the heating season, although the relative humidity may be high, the absolute humidity, the actual weight of moisture per unit weight of air, is low. When this air is heated, although the actual moisture content remains constant, the relative humidity is reduced to such an extent as to be exceedingly uncomfortable.

For instance, suppose the outside air at 20 deg. F., has a relative humidity of 50 per cent. This means that the actual moisture content is about 8 grains per lb. of air. When heated to a 70 deg. F. this 8 grains of moisture means a relative humidity of less than 10 per cent. When it is considered that for comfort the relative humidity should be about 35 per cent or the air should contain 38 grains of moisture per lb., it will be seen that 30 grains of water would have to be added to every pound of air circulated.

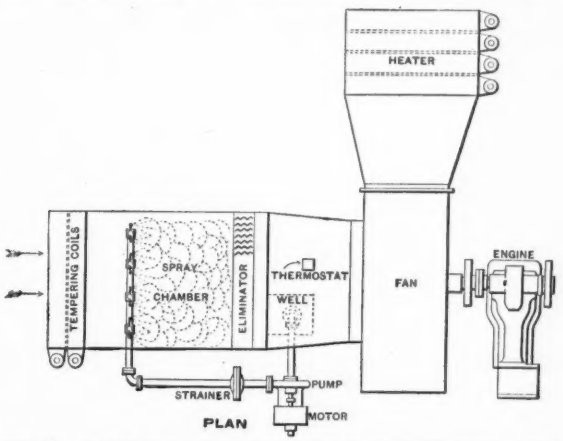


FIG. 1. DIAGRAMMATIC PLAN OF AIR CONDITIONING APPARATUS

Low humidities such as ordinarily exist in a building not equipped with effective humidifying apparatus are known to be detrimental to health as they cause dryness of the respiratory membranes, thus leaving them susceptible to the action of disease germs. Although it is generally recognized that proper humidification is beneficial, universal application has by no means resulted.

Moisture may be imparted to the air in different ways, the more common being by means of an air washer. In small installations a pan of water is simply placed in the path of the heated air. Even when heating coils are submerged in the evaporating pan, the results are entirely inadequate. Where practical the blowing of steam or mist directly into the air passages has been more or less successful.

Air Conditioning Apparatus

In the larger installation a washer forms the simplest and most flexible method of controlling humidity, and in addition it also filters the air of dust particles and objectionable odors. For humidity control it is only necessary to maintain a given relation between the temperature of the air leaving the spray and the temperature of the spray itself to obtain any percentage of humidity desired.

Air in passing through the spray tends to assume the temperature of the water and at the same time to become saturated at that temperature. When the outside temperature is very low it becomes necessary to preheat the air, first to prevent the freezing up of the spray nozzles and second to raise the temperature a sufficient amount so that the absolute water content at near 100 per cent humidity will be sufficient to produce the desired humidity at room temperature. From the spray, the air containing water in suspension is drawn through a series of baffles in the eliminator where this excess moisture is removed by fan or blower, and is then delivered through heating coils to the distributing ducts. The diagram shown in Fig. 1 will serve to give an idea of the general layout of the system.

Due to the cooling influence of the passage of cold air through the spray and also to the effect of evaporation, the spray water is rapidly cooled and it becomes

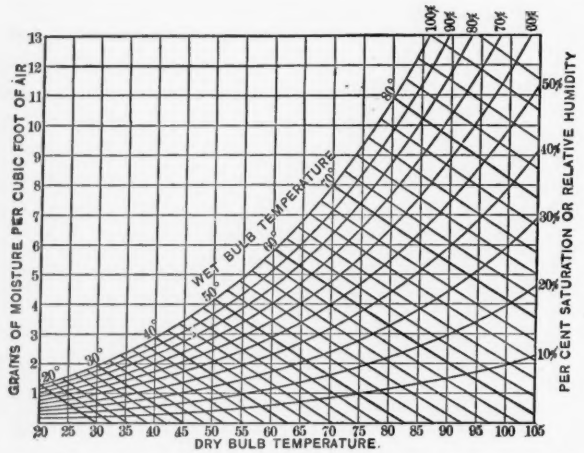

GRAINS OF MOISTURE PER CUBIC FOOT OF AIR
PER CENT SATURATION OR RELATIVE HUMIDITY
WET BULB TEMPERATURE
DRY BULB TEMPERATURE
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
20° 30° 40° 50° 60° 70° 80° 90°
20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105
1 2 3 4 5 6 7 8 9 10 11 12 13

FIG. 2. PSYCHROMETRIC CHART FOR DETERMINING CONDITION OF AIR

necessary to supply heat to maintain the desired temperature. This may be accomplished by the use of submerged steam heating coils in the spray sump, or simply by injecting steam directly into nozzle supply line. If the system is used during the summer months to effect ventilation with cool air it is necessary, unless a continuous supply of cold water is available, to resort to some method of refrigeration. Refrigeration may be effected by direct expansion in submerged tubes in either the spray sump or a separate reservoir, or by the circulation of cold brine.

To secure constant inside weather conditions irrespective of what the outside weather may be it is desirable that the conditioning apparatus be controlled as far as possible, automatically to eliminate the uncertain human element that accompanies manual control.

In one system of air conditioning apparatus, the dew-point, or saturation temperature of the air is automatically controlled by means of a thermostat located in the path of the air directly after it has passed through the spray. Obviously for any desired humidity at any given temperature the absolute humidity is fixed and so also the dew-point of that air. By adjusting this thermostat then at the desired temperature it may be made to operate either the steam valve in the nozzle coils of the spray sump or a mixing valve in the nozzle line, to maintain the correct spray temperature.

Final dry-bulb temperature of the air is regulated by a thermostat in the duct beyond the heaters which controls the steam valve to the heaters.

These two instruments, then, regulate the actual vapor content of the air and its dry-bulb temperature, thereby fixing its relative humidity which depends solely on these two values.

Testing for Humidity

Quantitative methods used in the laboratories for determining the actual weight of water vapor in a given sample of air give trustworthy results which do not depend upon previously acquired data for their accuracy but obviously they are not suitable for everyday use in checking up on relative humidity.

For the purpose it is necessary to know only two quantities, the wet—and dry-bulb temperatures, which are most readily found by means of a sling pychrometer, an instrument on which are mounted two thermometers one of which has its bulb inclosed in wicking which is wetted before use.

When the readings become constant, they may be noted and then the per cent of relative humidity may be found by referring to a psychrometric chart such as is shown in Fig. 2. Find the dry-bulb temperature on the lower edge of the chart then follow upward until the intersection with the wet-bulb temperature is reached. The per cent humidity may then be found on the curved line, interpolated if necessary, which passes through this point.

Calorimeter tests to determine the losses in calories of coal heated in the air for various lengths of time are being made at the Pittsburgh, Pa., experiment station of the Bureau of Mines, by J. F. Byrne. At 125 deg. C. the following heat losses were obtained:

Time of heating	Per cent loss
30 min.	0.30
1 hr.	0.26
2 hr.	0.311
3 hr.	1.01
20 hr.	3.3
46 hr.	5.7

Samples were heated for various periods of time ranging from ½ to 100 hr. and the B.t.u. run by the coal laboratory. The results show no regularly increasing loss in heating value as the time of heating increases. The coal samples show a change of weight on heating—at first, a decrease in weight due to the loss of moisture. The decrease is generally less up to 24 hr., when there is an increase in weight of 0.64 per cent. After heating 100 hr. at 125 deg. C., there is an increase in weight of 1.35 per cent and a loss in heating value of 3.02 per cent.

Traps for Boiler Feeding

EXPERIENCES IN USING THEM FOR BOILER FEEDING. SOME DIFFICULTIES ENCOUNTERED AND HOW THEY WERE OVERCOME. BY H. A. JAHNKE

FOR THE LAST 5 or 6 yr. the writer has been using return tilting traps for boiler feeding, and would not wish to return to the former method. Traps have many features in their favor as feeders, and also take care of the condensation from the heating system without any attention.

When installing traps for this purpose, of whatever make, the operator should thoroughly understand the action of the trap and the adjustments of the valves, or he may have trouble. This calls to mind the difficulty that I had with some traps shortly after they were installed because I had not given the adjustment of steam and vent valves sufficient attention.

It nearly caused a shut-down of the plant, for the water was going down in the boilers and was almost at the danger point before the trouble was found and remedied, all due to my ignorance and lack of foresight. One day the steam and exhaust valves started to leak badly so that the trap furnished just about enough water to keep the boiler working. I managed to get along until noon, then removed the valves and reground them; but after we started up the trap still failed to give sufficient water to keep the boiler working safely.

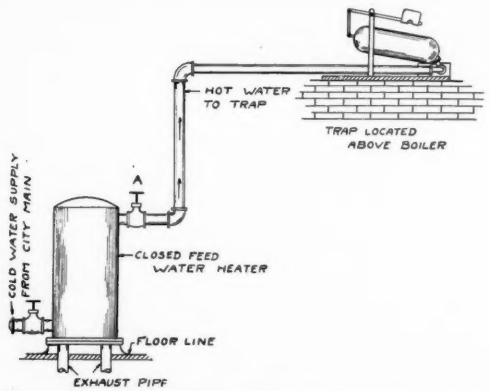


FIG. 1. FEEDING BOILER THROUGH HEATER AND TRAP WHERE CITY PRESSURE IS AVAILABLE

I was sure that the valves were not leaking, but still the water kept getting lower in the boiler and something had to be done.

In watching the trap operate, I noticed that the action was slower than usual and concluded that the pressure in the trap tank was not released as quickly as it should be, which prevented the trap from filling as rapidly as it should. Looking in the instruction book that came with the trap, I found that I had not adjusted the vent valve as directed, hence the pressure was not relieved after the trap came back to filling position. With this adjustment made, there was no further trouble in getting plenty of water to the boiler. Always since I have made it a rule to know my trap before starting to operate it.

Some advantages of traps that I have found for boiler feeding are: low expense and little labor to keep them in operating condition; no lubrication bother or waste of cylinder oil; no loss of steam or of condensation; no repacking except of the trunnions; no leakage if the trap is kept in good condition.

PACKING SAVED

IN A TRAP, the only parts that need packing are the trunnion joints and the steam and exhaust valve stems which will need new packing every 8 to 12 mo. This is a simple matter, taking but a short time and requiring but little packing of inexpensive type.

LITTLE ATTENTION

SOME ENGINEERS are of the opinion that a trap can be so regulated as to maintain the water level in the boiler constant. There should be no trouble in doing

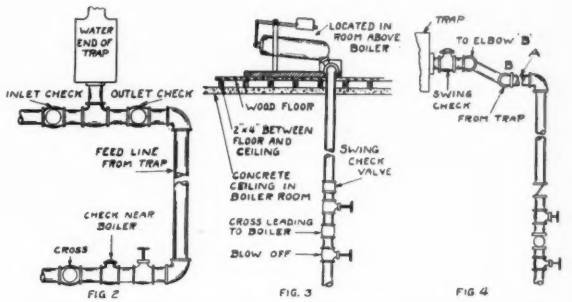


FIG. 2. ARRANGEMENT OF CHECK VALVES WITH BOILER FEEDING TRAP

FIG. 3. RIGID CONNECTION BETWEEN BOILER AND TRAP

FIG. 4. FLEXIBLE CONNECTION TO TRAP

this if a trap of the proper size is used and the supply of water to the trap regulated by a valve so as to be steady.

Each morning after the plant is in operation, I open the steam valve to the trap and the valve in the water supply to it a certain distance, going by a mark that has been found to give the desired rate of boiler feeding. I do not go near these valves again until it is time to close down for noon. The same routine is repeated for the afternoon run. The water level in the boiler varies but little during the day's run from what it was in the morning.

HEATING THE FEED WATER

IN CASE the water is to be fed to the boiler warm, many operators believe that a trap is expensive as the trap must be placed 4 or 5 ft. above the water level of the boiler in order to feed the water in. In some plants this arrangement is difficult to secure on account of getting the water to the trap. Where city water is used under pressure and a closed heater, the piping can be arranged so that the water enters the heater under pressure and is forced to the trap. Then a lifting trap will not be necessary. This idea is illustrated in Fig. 1. Feed to the trap can be regulated by valve A.

If the feed is not under pressure, it will be necessary to use two traps, one to lift the water up to the trap above the boiler, the other to deliver into the boiler, but

the arrangement is not difficult if the steam pressure is sufficient to lift the water the required height. In one plant we have to keep the steam on all night in cold weather and as there is no night watchman, there was trouble in returning the condensation to the boiler which was left with banked fires which would keep up the pressure. By using the two-trap arrangement there is seldom any trouble, as the traps will work continuously unless the steam pressure falls so low that the lifting trap cannot operate, which seldom happens.

I am not a salesman for traps nor an advocate of any special make of traps, but I am giving the facts as I have found them and my experience in using traps for returning water to boilers.

Some Trap Troubles and Remedies

Most tilting traps have an inlet and an outlet swing check valve as shown in Fig. 2. My traps are arranged in this way. One day the trap stopped operating, and in

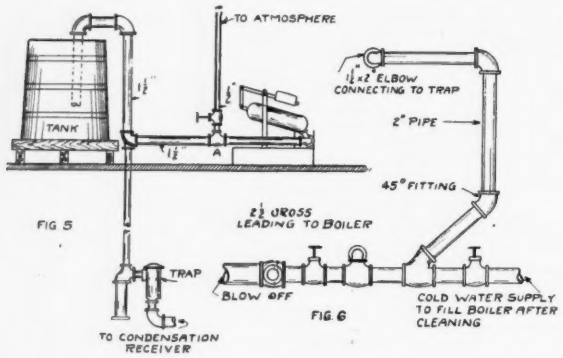


FIG. 5. PIPING TO RELIEVE PRESSURE QUICKLY AND TO DRAIN EXHAUST PIPE

FIG. 6. PIPING TO CUT DOWN FRICTION OF FLOW BETWEEN TRAP AND BOILER

looking for the trouble, I found the outlet check near the trap, also the check in the feed line near the boiler leaking so much that there was nearly full boiler pressure in the trap tank when the trap was in filling position. This prevented the trap from filling.

I knew that the checks were in good condition, so that something must be holding them open. I placed the trap in dumping position and turned it to filling position a few times so as to open and close the steam valve, and this allowed the steam to blow through the checks so as to carry away the foreign substance that was holding them open, for shortly after the trap started operating again as well as ever.

In another instance, the trap failed to feed sufficient water to the boiler although it was operating at its usual speed. There could be nothing wrong with the water supply, and at first I thought that the blowoff valve was leaking badly, but inspection showed that this was not so. In examining the trap, I placed my hand on the water supply pipe near the trap and found it quite hot when the trap was discharging. This located the trouble. The inlet check valve was leaking so that some of the water backed up from the trap, when it was discharging, into the water line and only part of the water was discharged to the boiler. Regrinding the check valve cured the difficulty.

Trap Foundations

Frequently traps are placed on a foundation of wood. As there is always a little leakage at the joints of the trap, the wood soon becomes soaked and rotten, allowing the trap to settle and putting a strain on the piping, sufficient in some cases to break the joints.

Again, some users of tilting traps do not realize that as the trap moves there is a jar that will cause strain on the pipe joints unless the trap is placed on a solid foundation. A trap should have a good solid foundation that will keep it at all times in alinement with the piping and avoid bringing strain on the joints, otherwise there will be trouble sooner or later that may cause a shutdown of the plant.

In one plant where a tilting trap is used for boiler feeding, the trap is located in a room above the boiler, the ceiling of the boiler room being of concrete and a wooden floor laid on this in the room above. The trap was placed directly on the wooden floor, with the discharge pipe running directly from the trap to a cross leading to the boiler feed and blowoff pipe as shown in Fig. 3. This allowed no flexibility at any of the joints between the trap and the boiler, and when the floor rotted and the trap began to settle, a heavy strain was placed on the blowoff pipe where it came through the brickwork, increased by the jar of the trap when it was dumping.

To remedy this, a concrete foundation was placed under the trap and at the same time the trap was moved so that a short horizontal run of pipe was introduced in the discharge from it, giving some flexibility between the trap and the boiler connection as shown in Fig. 4.

Releasing Pressure Quickly

Sometimes there is trouble from the steam valve on a boiler feed trap leaking so that the pressure in the trap does not relieve quickly when the trap is returned to filling position. This makes the trap operate slowly, and there may not be time to take out the valve and regrind it until closing time. In such case the trap can furnish just about enough water to keep the boiler going, and if the leak becomes worse it is necessary to shut down to regrind the valve. To avoid this, I arranged the exhaust pipe as follows, shown in Fig. 5. Exhaust from the trap is discharged into a hot water tank, which causes a little back pressure so that the steam does not escape from the exhaust pipe so quickly as it would if the discharge were to atmosphere. If the steam valve leaks, this delay is increased. To relieve the pressure quickly whenever the steam valve leaks, I placed a tee in the exhaust line near the trap as shown at *a*, and ran a ½-in. line with a valve in it to discharge at atmosphere. When the trap gets to operating slowly, this valve is opened, allowing part of the steam to discharge freely and thus relieve the pressure quickly. After the steam valve is reground, the ½-in. valve is closed and all steam is discharged into the tank. The line leading to the tank is 1½ in. and the reason for using ½-in. for the line to atmosphere was that in this way most of the steam goes to the tank even when the ½-in. valve is open so that the heat is saved.

The exhaust pipe from the trap is drained of condensation by a vertical pipe leading to a small trap as shown, so that the horizontal run is always free of water thus avoiding water hammer. Condensation from this

small trap is sent to the condensation receiver and returned to the boiler so that no condensation is wasted.

Inlet and discharge to my boiler feed trap are 1½ in. and to reduce drop in pressure as much as possible, I increased the diameter of the pipe to 2 in. from the trap up to the connection to the blowoff as shown in Fig. 6. I also used a 45-deg. tee connection and elbow so as to avoid a sharp turn of the water when entering the feed pipe and used 2½ pipe from the feed line to the boiler. In this way I find that the trap works quicker and gives better results.

Remedy for Lifting Trap Troubles

When a lifting trap is used for forcing the water from a heating system or other sources to the tank of a direct return lifting trap, the direct return trap must always be in good working condition or there will be trouble. In our plant where we have this system and it works all night with the boiler fire banked, we had no trouble and there was always plenty of water in the boiler in the morning until one day I noticed on coming to the plant that there was but little steam left in the boiler and the water was quite low in the glass. At first I thought that the lifting trap had failed to work during the night, but I found it in dumping position and no water being forced to the direct return trap. I laid this to the pressure being too low to force the water up to the higher trap, but on examining the direct return trap, I found that it would not go into dumping position because the balancing weight had shifted so that the tank could not tilt even when it was full of water. The lifting tank could, of course, not force more water up until the upper trap had discharged, so the whole system was blocked. After adjusting the balancing weight there was no more trouble. I made sure that this would not happen again by fastening the weight with the bolts provided for the purpose and securing them with lock nuts.

Another safeguard which we had in use saved the system from a possible freeze-up. Had there been no overflow pipe on the condensation receiver, the water would have backed up into the heating system, and might have frozen; but as it was, the condensation escaped from the overflow, and nothing worse than low water in a banked boiler resulted.

In another case where the same arrangements of traps was used it was noticed that not all the condensation from the heating system was returning to the boiler, for more and more make-up water had to be supplied. For a time this was a puzzle, as there was nothing wrong with the lifting trap nor with the piping. But it was found that the trap was not dumping as frequently as usual with all the heating system turned on, which was sure proof that some of the condensation was escaping before it reached the receiver.

Part of the return pipes were run under a concrete floor and down to the receiver as shown in Fig. 7, and we guessed that the leak might be there. Tearing up the floor and clearing away the concrete, a place was found where the pipe was rusted through and the water gradually leaked away through the concrete. Repair was made by clearing away sufficient of the cement so that the damaged part of the pipe could be cut out, the remaining ends threaded with a ratchet die stock and a new section with a union at each end put in place. The difficulty with rusting of this pipe and the fact that it might have involved tearing up a long stretch of floor and moving several machines to find the leak, emphasizes the fact that pipe should never be laid solid in such a floor. A pipe trench should always be made of concrete and the pipes laid clear of the walls so that they can be readily inspected and repaired; and in the case of pipes carrying steam or hot water they should be insulated with pipe covering to prevent loss of heat.

Checking Steam Wastes

In arranging and operating traps for return of condensation to boilers it is possible to save much steam by the use of common sense and care. The traps should be arranged so that they are operated no more than necessary to take care of the condensation, as such extra operation results in the waste of steam. I know of one plant where a tilting trap was used to lift condensation from the heating system to the tank of the boiler feed-

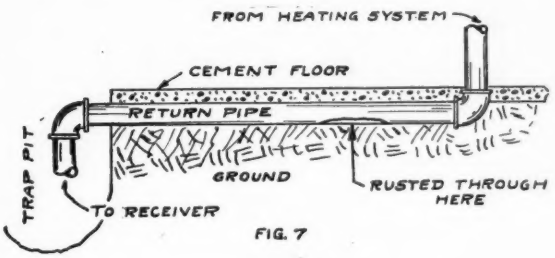


FIG. 7

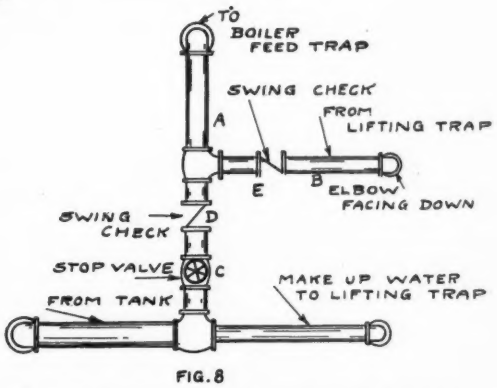


FIG. 8

FIG. 7. CAUSE OF TROUBLE IN RETURN SYSTEM
FIG. 8. FEEDING MAKE-UP WATER TO EITHER LIFTING OR FEEDING TRAP

ing trap and the make-up water, of which there is considerable in the daytime due to the use of steam for industrial purposes, was put in through the lifting trap when it might as well have been put directly into the feeding trap thus avoiding so frequent operation of the lifting trap. The make-up water was warm from tanks heated by exhaust steam so that there was no need of putting it through the lifting trap to heat it; but in the case of cold water used for make-up, it might well be worth while to send the make-up water through the lifting trap for the sake of heating it as much as possible before feeding it to the boiler.

In another instance, where lifting and feeding traps are used, as shown in Fig. 8, the piping is so arranged that the make-up water can be led to either the lifting trap or the feeding trap, the regular feed coming to the lifting trap from a tank. Swing checks at E and D con-

trolled the backing up of water either into the make-up line or into the lifting trap discharge, so that the valve C was usually left open during the time when the lifting trap was in operation to let the regular feed up to the feeding trap.

At one time, it was noticed that too much make-up water was being used when all the heating system was on and there should have been sufficient regular feed to meet nearly all the needs of the boiler. Examination showed that valves D and E were leaking, so that when the lifting trap dropped into discharging position at the same time that the feeding trap was in dumping position, the lifting trap would force its discharge into the water tank through the valve E. There was not much loss of power in this performance, as the water was fed back to the feeding trap by gravity from the tank, but there was a loss in heat as the water sent to the tank and returned was cooled. The trouble was over come by closing the valve C while make-up water was

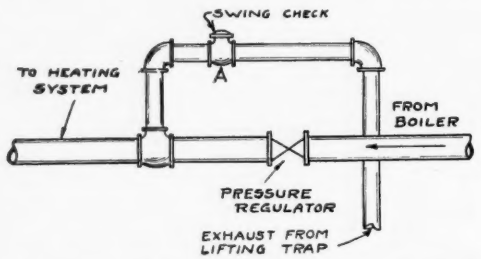


FIG. 9. CAUSE OF BACK PRESSURE IN TRAP TANK

fed, then opening it and closing a valve in the tank line during regular feeding, this method being followed until the valves could be removed and reground.

In one other case where the exhaust steam from a lifting trap was discharged into the low-pressure heating system through a swing check valve, A, Fig. 9, it was seen that the trap was not operating, and observation showed that the pressure in the trap never dropped below that of the heating system, so that water could not run from the condensation receiver into the trap. The check A was leaking so that pressure from the heating system backed up all the time into the trap, and could not be relieved. Regrinding the valve so that it closed tight stopped the trouble.

Repairs on Traps

If the steam and vent or exhaust valves are kept in good condition, traps will seldom give trouble; but these valves should be looked over frequently to make sure that they are all right, not let go until they show signs of giving trouble. Inlet and outlet check valves should be given the same attention.

If the steam valve leaks, the trap will fill only slowly so that it will not operate as fast as it should. If the vent valve leaks, there is a loss of steam when the trap is discharging and the trap is also slower in action when in the dumping position. A leaky water inlet valve will allow some of the water to back up into the supply line during discharge, thus cutting down the capacity of the trap and wasting some of the steam that enters the trap during discharge. If the check in the discharge line leaks, it may often be the case that the check in the boiler feed is also leaking, and this will allow boiler pressure to build up in the trap, preventing it from filling with water. These results show how important it is that all valves be kept tight at all times if trouble is to be prevented.

As steam and discharge valves in the traps which I use are removable and have regrinding valves and seats, I keep a spare set on hand, so that in case of a leak, the valve and seat are removed, the spare set substituted in a few minutes, and the leaky set reground at the first opportunity. This saves time and labor, for it is easier to regrind at the bench than in the trap, and avoids shutting down the trap, which is often of great importance when it is working to capacity.

Knocking Around in Texas

A Typical Case of Haphazard Power Development—Texas is Not the Only State That Can Boast of Plants Like This. By John Pierce

JUST a few miles above the beautiful little town of New Braunfels, Texas, is a range of hills from the sides of which flow great springs of pure clean water, never failing in their flow, nor the amount of it. The water from these springs, coming together along the base of the ridge, form a deep swift flowing river, clear as crystal and almost as cold as ice.

Looking ahead into the future, and foreseeing a good sized little city in the coming years, the old original Landa with his true German thrift, secured not only a vast acreage of land along the stream, but also took pains to locate so that the power from it could be utilized with but little cost. In those days he was scoffed at as a dreamer of dreams; but later, a good railroad came through, and then another, and both built stations at the point across the river opposite his holdings. It was then that he conceived the idea of a "gin," and persuaded his German followers, who were then coming into this part of the country, to settle and to plant cotton. Following his advice they did so, meanwhile constructing his gin, and installing as motive power a huge water wheel.

The Town Puts in Electric Lights

As the years rolled on, the village grew into a fair sized town and, as towns will, elected a mayor and a bunch of city dads. These men decided that, in order not to be shamed by their neighboring towns, they should have electric lights, and approached the Landa concern with a proposition to furnish them their current. Mr. Landa, seeing that it was a very good thing, agreed to it and made arrangements accordingly.

His first move was to set up a power plant, and knowing by experience that the power of his wheel was not sufficient to do the work, he installed a twin hydraulic turbine wheel belted to a 250-kw. two-phase alternator. A rough sketch of the grounds as they are now laid out is shown in Fig. 1 and this first installation is now honored by being designated as power house No. 1. This wheel has run constantly, with the exceptions of

the few hours when it has been shut down for the purpose of minor repairs. It has a panel in the same room as the generator which is located over the wheel and slightly to one side in order to obtain belt centers of sufficient length.

Later the city called for more power, and it was found necessary to install another machine, which was done, but at a point some distance from the first plant, and this was, and is, called power house No. 2. This plant is equipped with a unit the exact counterpart of No. 1 as regards wheels and generators; but as it was then hoped that more units would in time be needed, it was decided to make this generator room also into a main panel room, for both the units already installed, and large enough to take care of additional units at some future date. Each unit has its own individual panel at its side and so arranged that should that one alone be called into service and the others all cut out, it can be controlled by its own panel and the main panel cut out. This makes a very handy arrangement for the operator, as some of the units which were added later are some distance from the main panel room.

A Municipal Plant is Installed

Shortly after the installation of the second unit the city dads decided that they also needed water mains in their town, and as the river of good water flowed through the center of it, felt that it was foolish to go on making Mr. Landa rich, and so would put up a pumping plant of their own, and would equip it with motor driven pumps. By building their own light plant they felt they could save lots of money for the city as well as get the city a source of income that would help pay other expenses. At this point it is probable someone thought there was a chance for a little private graft, for instead of investigating the costs of operating and upkeep they went blindly ahead and put up their plant and installed a couple of Diesel engines. I could not learn what type engines they were, for they are under lock and key and I could not find who had the keys; my information of this particular point coming from a citizen of the little city.

At any rate, they found that it was not possible to employ several operators, pay the fuel costs and upkeep, and still produce current as cheaply as Mr. Landa was selling it to them from his water wheel driven generators, so they finally went back to the old arrangement and now the Landa people are furnishing the city with all its light and power, and have taken over the few lines the city installed in addition to the Landa lines already up. The water works requirement for current now coming in on the company, it was found to be necessary to add on another unit. In the meantime, they had branched out considerably, and in addition to the gin a large oil mill had been added and the capacity of the gin increased, so that much more current was needed. In the building of this other property, they had built in the way of the river somewhat, so an oil engine was decided on for their third plant.

A 350-hp. Diesel engine was installed in power house No. 3. This unit is direct connected through the generator, which is a 250-kw. two-phase machine, and the exciter which is mounted between the main bearing—outboard—and the Ingersoll-Rand compressor. The compressor is 9 and 5¾ and 2¾ by 10 and has always given excellent service. The engine, however, has not been so good, having broken two crank-shafts, the first of which was thrown away, and the second welded and replaced. The engine has cracked one head only, but has hardly ever been run without breaking a few springs or some other little thing that in itself does not amount to much, except that it causes considerable work and delay and more or less disgust. This plant is in a nice large building, as, in fact, are all the power houses, and has a cross track overhead crane carrying a 2-T. set of chain blocks. The air bottles are nicely arranged and all the valves and piping are well placed. The engine starts by motor, and so one can easily "lose his air" and yet not worry about how he is going to get her going again. The hand oil pump has been discarded, and a small motor does this little job also.

Engine is Afflicted With "Jazz"

One trouble, and perhaps the source of all the trouble, is that when the engine was set up the foundation was faulty, and the engine seems to have been not properly placed, for when in service it wants to walk around and look out the windows, and at the present

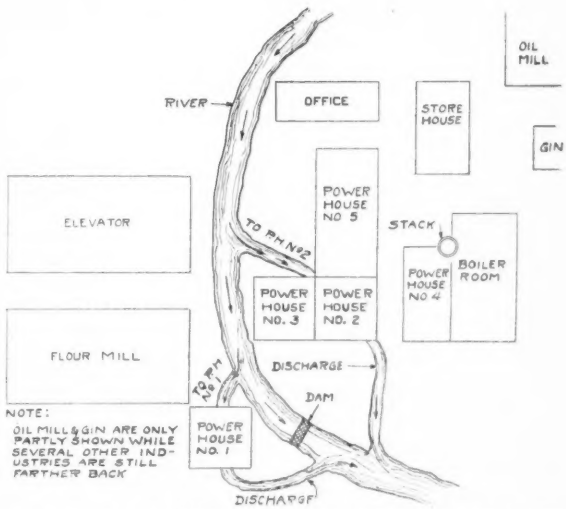


FIG. 1. EACH TIME MORE POWER WAS NEEDED A NEW PLANT WAS BUILT

time is devoted to the arts of the "jazz" and has even tried to "shimmy."

This engine runs about 50 per cent of the time in the summer and very little in the winter, and while it runs much more economically than the steam turbine, it has not the capacity the turbine has and is therefore not run except as an auxiliary or emergency engine. The operators say that it is impossible to overload it, for when it has reached the 90 per cent point of its rated capacity it stops pulling. It was installed 10 years ago, and has not been used at any time since the first year except as stated, although it did run constantly the first year.

Now we come to the place where the company decides to branch out some more, and we find that a large flour mill has been built with its accompanying elevators, corn mills and rye mill. Again the power was found to be insufficient and so power house No. 4 was built, and in this plant was placed a 500-kw. Curtis steam

turbine direct connected to a two-phase G. E. alternator. This machine is operated at 140 lb. steam pressure, with superheat, is run condensing, and has run practically constantly for 4 yr. and has given not one minute's trouble to date. On its last inspection the blades were found to be a little worn and somewhat pitted, but were not removed, although a new set is kept on hand and in readiness to install at any time they are needed. This machine, like all the rest, has its own independent panel though connected also through the main panels at the main board. This engine and the two water wheels are run constantly, day and night, and furnish in the spring of the year, all the necessary current, though later in the season one of the other engines must be cut in for a few hours each day while the peak is on.

When this engine was installed, a small Hamilton Corliss was purchased and set up in what is called power house No. 1. The engine is a girder frame 14 by 36

JOS. LANDA

DAILY ENGINE ROOM REPORT

RUN Night / Day \ Steam Turbine / Water Wheel

Engineer

New Braunfels, Texas, _____ _____ 192_

	7	8	9	10	11	12	1	2	3	4	5	6	Ave
Ind. K.W.													
Steam Pressure													
Vacuum													
Superheat No. 1													
Superheat No. 2													
	7										7		Total
Rec. Meter K.W.													
Fuel Oil													
Oil Qts													

MULTIGRAPH

FIG. 2. AT THE END OF HIS RUN THE ENGINEER ON DUTY HANDS THIS REPORT TO THE CHIEF

machine running at 125 r.p.m. and has a belt-driven two-phase 250-kw. G. E. alternator tied onto it with a belt center of 65 ft. Its generator stands in the dynamo room of power house No. 2 at the side of the No. 2 generator, and it was primarily intended for an auxiliary to the steam turbine; but it has probably never run more than 200 hr. all told, and is now for sale, for they have found that it is not large enough to "go it alone" and do any good.

Oil is Used for Fuel

Of course the installation of the steam engines called for the erection of a boiler plant, and two 250-hp. Murray water tubes were set up, and one 500-hp. Page-Burton water tube. These were at first fired with coal, cobs, and other refuse from the mill, but later oil was placed under the two Murrays and it was then found that by using the Page when necessary to wash the others, it was possible to cut out the Page and pull all the load with the other two, and since the turbine runs condensing and but very little make-up water is needed, the boilers do not require washing except at rare intervals.

The boiler room is a very large place and nothing is at all crowded, in fact, this was one of the peculiar things noted at this company's property, for in every building or powerhouse one finds worlds of room and nothing is crowded.

The steam, before going to the condenser, passes through a large closed heater, and the make-up water is heated before entering the boiler, as well as the water from the hot well. The boilers are fitted with draft gages and 3½ in. is carried when firing at full capacity, though 10 in. is available in case of necessity. The brick stack is 10 ft. inside diameter at base and is 125 ft. high. Marsh feed pumps in duplicate units furnish water for the boilers while duplicate units of the Worthington type are used for the oil feeds. Oil used is crude and is very light.

Records Make Good Bonfire

Soot blowers were originally used while using coal, but when oil was installed the blowers were removed, and thought to be not necessary, though now they find that it would have been better to have left them in and are about to replace them. All pressures, voltages, amperages, and kw.'s are kept on recording instruments and are carefully filed away in the box made for them at the No. 4 powerhouse, though the engineer says they are never looked at from the time they are taken from the instrument until they are burned at the end of the year. Various burners have been used under these boilers and discarded in favor of others, though in changing burners several times the arrangement of the furnaces has never been altered. Why this was done will be told farther along in my article.

In the Diesel engine plant, we find thermometers and compression gages, but the compression gages are now disconnected. All water outlets are in plain sight so that the operator can see at all times, just what she is doing as regards getting hot. As before stated, all machines have their respective place on the main panel and are controlled from there. All machines are controlled by Tirrill regulators except the one driven by the Diesel engine and the men on the floor say that it is very difficult to control that particular generator by hand. Another interesting thing is that every machine can be in service at the same time simply by cutting each one in on a separate circuit or any two can be thrown together and operated in parallel. Again, by combining two circuits two sets of two machines each can be operated in parallel—that is one set operated in parallel on one circuit, while the other set is run in the same manner on another circuit,—while the fifth machine handles its load alone.

In Fig. 2 is shown the report which is made out by the floor engineer and handed to the chief at the end of his run which, by the way, is a 12-hr. service, and at the end of the month the chief makes out the one shown in Fig. 3 and hands it to the chief bookkeeper at the office. The daily consumption of oils is entered in a small paper back book and thrown away when the book is full, and this is the only form of record kept in all this system of plants.

Guessing Forms Important Part of Operating

The engines have never been indicated and they have not the least idea as to just what their machines are doing except in a general way. The firemen note, on a stick, the number of inches of oil used in their run

of 12 hr., and the engineer notes how much lubricants he has used and what kind. At the end of the month, these are all totaled and sent to the office on the monthly report sheet which is here shown. In the changing of burners, I found that no tests were made to determine the good or bad quality of the burner and that one kind was discarded because it would get stopped up easily, and another was thrown out because the fire it made did not look white enough. Soot blowers were removed because the rows of tubes which were exposed to the eye in the furnace showed no soot, though the baffle plates were never examined to see if any was being collected there to the detriment of the tubes between them. The turbine runs and the amount of current registered on the output meter is used as an indicator, and compared to the amount of fuel consumed. Thus is found the fuel consumption per horsepower-hour.

MONTHLY REPORT

Fuel Consumption And Electric Power Production

Month Of _____ 192_

WATER POWER

Total K. W. Hrs. produced at O. M. Turbine _____

Total K. W. Hrs. produced at F. M. Turbine, as follows:

Gross City Reading, Light & Power

Less Brewery, Crusher, City Water Wks., Pwr. _____

Net K.W.H. produced at F. M. Turbine _____

Total K. W. Hrs. produced by Water Power _____

FUEL POWER

K. W. Hours produced by Steam Turbine _____

K. W. Hours produced by Diesel Engine _____

Total K.W.H. produced by Fuel Power _____

Total K.W.H. produced by Fuel & Water Power _____

Less Gross City Reading (Sold to Customers) K.W. Hours _____

Balance is amount used in own plants _____

Oil Consumed, Steam Turbine, Gallons _____

Oil Consumed, Diesel Engine, Gallons _____

Coal Consumed, Steam Turbine, Tons _____

Total Light, Mdse. & Power Revenue, month ending..... _____

Lands Mdse included in above _____

Customers Mdse included in above _____ _____

Total amount of power charge included in above _____

Note: Total K.W.H. produced by O. M. Water Turbine is reported by engineer at power house. Total K.W.H. produced by F. M. Water Turbine is the small meters and all lights; to get this deduct from total of city reading the power used at the Brewery, Rock Crusher and City Water Works.

FIG. 3. WHEN THE END OF THE MONTH COMES THE CHIEF HANDS THIS REPORT TO THE HEAD BOOKKEEPER

At the office, I found every courtesy shown, and books were hunted through for my benefit in order to see if there ever had been any system of record keeping and testing; but the kind old gentleman who manages the estate told me there was none, and never had been.

Engineer Is a Busy Man

Perhaps some of you will say this is a deplorable state of affairs, and perhaps I should agree with you, only you would not say so if you knew that in these small southern towns one has to do many things in order to keep things on the move, and the chief of these plants is no exception. He has the lines all to look after, and all the motors as well as all the new installations of power of any kind, and all the removals and changing of meters as well as the calibrating of them. He has these five plants to attend to, the machine shop which has one mechanic and that himself, the rewinding and repair of motors, the belting, shafting, and in fact he has enough work to keep three good men busy. He is asked to do it all himself, and he is making a heroic effort to do so. Therefore it is no wonder that the man finds no time to make tests and to keep records.

I have always thought I was some manager when it came to covering a lot of ground and getting around a pile of work, but I take my hat off to this man for I don't know what work is. He is allowed only two firemen, two floor engineers, and two Mexicans for outside work, yet his plants are really models, for there is not one single leak in any place in all that system. Every joint is tight, every valve stem is packed, and every gland is holding, and over all everything is as clean and neat as any woman's parlor. Not a grease spot, and in powerhouse No. 2 we find rugs on the floor; every bright piece bright and shining, every machine functioning in a proper manner, and every man on the place happy. How many of you fellows can say the same thing about your place, even though you have all the help you need and all the advantages of nearness to every kind of supplies and materials?

Coal Situation Somewhat Easier

Public utilities and industries have an average of about 45 days supply of coal on hand, according to an investigation made by the Chamber of Commerce of the United States. While this supply is less than normally carried, it appears to be adequate for current needs. In general the situation is somewhat easier, especially in the bituminous field, although the Great Lakes states and New England will face the problem of securing a sufficient domestic supply in advance of cold weather.

Retail dealers have practically no stocks on hand, as the coal is being delivered to the householder as rapidly as received. In certain localities, the householder is not taking advantage of the opportunity to secure available coal to protect himself against emergency which would result from an early winter with a consequent demand for coal in excess of transportation facilities. Some of the cities have therefore developed effective systems for gathering information and distributing their coal, the object being the protection of the small consumer. Different methods have been used for securing this information such as statements of stock on hand made by purchaser when ordering, or checking by delivery men as to the supplies in the bins.

The investigation also shows that there is increasing interest being taken in the use of oil and coke for domestic fuel.

Copy of Power Plant Engineering Desired

The Library of Congress has requested us to furnish them with a copy of the January 1, 1920, issue. As our supply is totally exhausted, we are calling on any of our readers who may be willing to part with a copy. If sent to us, we will see that it is sent to the proper party.—Editor.

Care of Oil Engine Bearings

IMPORTANCE OF BEARING ALINEMENT; CAUSES OF UNEVEN BEARING WEAR; HOW TO CHECK AND CORRECT BAD CASES. BY M. S. HOWARD

ONE OF THE first things the operator of an oil engine must understand is that the crankshaft bearings must be kept in line. It formerly was quite the custom to ascribe the breaking of crankshafts to crystallization of the metal or to improper heat treatment of the metal during the forging of the shaft. Other explanations have been offered; such as hydrogen embrittlement, meaning that during the heating of the billet, hydrogen was encased in the steel and upon meeting with oxygen left the metal and weakened the structure.

SHAFT FRACTURE CAUSED BY MIS-ALINEMENT

OF LATE, investigation of many fractured shafts has proven that in all these cases of damaged oil engine crankshafts the cause of the fracture could be traced to misalinement of the main journal bearings. It is not claimed that no shaft has been broken by other causes; precaution, he should be held responsible if an accident occurs.

The question naturally arises—how may the engineer keep the bearings in alinement and how may he learn whether one or more are low? A moment's consideration will cause one to concede that it is impossible to expect babbit bearings to wear at the same rate even though the pressure be the same. In the actual engine, it is quite customary to find the combustion in the several cylinders to differ quite radically. Often the cylinder pressures vary as much as 25 per cent. This means that 25 per cent greater pressure is exerted on the two main bearings adjacent to this cylinder than upon the remaining ones. With the same babbit liner, these two bearings will wear faster. This means that soon the shaft has a preceptible kink in it and at each revolution is flexed back and forth. Finally the shaft gives way.

A second cause of rapid bearing wear is a difference

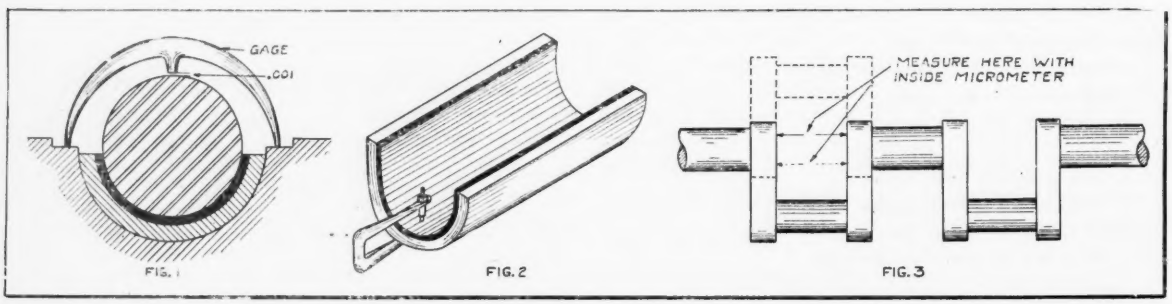


FIG. 1. SHEET METAL GAGE MAY BE USED TO CHECK HEIGHT OF SHAFT AT EACH BEARING HOUSING. FIG. 2. MICROMETER MEASUREMENTS OF BEARING SHELL GIVE INDICATION OF BEARING WEAR. FIG. 3. VARIATION IN WIDTH BETWEEN CRANK WEBS, WITH CRANK AT TOP CENTER AND BOTTOM CENTER, SHOWS SHAFT DEFLECTION

but of those examined, all showed at the fracture signs of the edges of the fracture having rubbed together by reason of the bending of the shaft, and upon checking the bearings in all cases one or more bearings were found to be low.

It has been proven by experiments at the University of Illinois that a shaft that is forced to bend at each revolution, as in case of uneven alinement, will run a definite number of revolutions after which it will break. The total number of times before fracture depends upon the metal, the diameter, and the amount of flexure. If these factors are known, the length of shaft life may be predicted with fair accuracy.

No set of shaft bearings are ever absolutely in alinement—even when leaving the test floor, the discrepancy will be around 0.001 in. With this amount of flexure the shortening of life is negligible, but when the discrepancy amounts to 1/32 in., the shaft life is reduced as much as 90 to 95 per cent. Since the crankshaft of a 500-hp. Diesel engine costs from $7000 to $9000, the advisability of keeping the shaft as near level as possible is obvious. No shaft should be allowed to run for any length of time with a low bearing. If the engineer is so careless as to ignore this sound engineering in the grade of babbit or in the amount of peening done on it. The softer babbit wears faster, throwing the shaft out of line.

The engineer is then confronted with the problem of how to avoid this trouble. He cannot alter the character of the babbit put into the bearing shell, but he can control the cylinder pressures. For this reason, he should purchase an indicator and occasionally take indicator cards from each cylinder. If the compression pressure in one of the cylinders is higher or lower than the others, it should be brought to its correct value by placing additional shims or removing some of the shims from between the big end of the connecting rod and the crankpin bearing. If the injection period is longer or shorter in one of the cylinders, by shifting the fuel cam nose the correct injection period can be obtained.

These are the ways in which the bearing wear may be kept as near uniform as possible. But the engineer is confronted with the question of how to check the shaft alinement to find if things are in proper condition. Two methods may be followed or a combination of both.

SHEET METAL GAGE FOR CHECKING BEARINGS

THE FIRST method to be outlined is the easier one and for this reason it is probable that it is preferred by

the majority of those engineers who attempt to keep the shafts in alinement.

A gage, as shown in Fig. 1, is made up out of sheet steel of, say, ⅛ in. thickness. This gage is so made that when its two legs rest upon this bearing housing the anvil just clears the shaft by 0.001 in. Gages should be made for each bearing and numbered so that no mistake can be made. If the engine is a highgrade one and has had the housing planed and bored at one setting, the housing are all in alinement. One gage only is needed under such circumstances.

Now, if a bearing wears, the shaft will, of course, bend until it rests upon the babbit. This, then, causes the shaft surface to be lower than before the wear occurred. If the gage is now placed on the bearing, the clearance between the shaft and gage anvil will be more than the original 0.001 in.

A second method is more accurate and is largely used by the traveling inspectors sent out by oil engine builders.

The majority of engineers have the housing all bored for the bearing shells at the same time. The only difference in the misalinement of these housings is the slight inaccuracy of the boring mill. This difference should not be over 0.001 in.

Micrometer for Measuring Bearing Shells

The babbit metal is cast into a steel or cast-iron bearing shell. These shells rest in the housings and are within 0.001 in. of being true. The difference in bearing heights will not exceed 0.002 in. If this thickness of the bearing shell was known, then any later wear could be detected by a decrease in the thickness of the bearing shell. A large gap micrometer may be secured from any gage maker. This is similar to that shown in Fig. 2. By measuring the bearing shells when the engine is erected, any wear and shaft misalinement can be detected by rolling the shell out and remeasuring the thickness. This should be done at a point about 2 in. from each end of the babbit liner. This should be done about every 6 mo.

Limits of Allowable Bearing Wear

Naturally the question arises,—how much bearing wear and shaft bending can occur and still not require new bearings or readjustment? The allowable wear will vary in different sizes of engines. For engines over 200 hp., the difference should not exceed 0.008 to 0.01 in. Smaller engines, having smaller shafts, can of course stand a greater variation, say up to 1/64 in. On the other hand, hundreds, probably thousands, of semi-Diesel engines, are running with bearings as much as 1/16 in. out of alinement. I have found some that were out 3/16 in. That such engines do not break their shafts speaks a lot for the high quality of the steel used in the shafts.

The engineer who finds that the bearings are out of alinement is now up against the problem of realining them. Many raise the low bearing by putting shims under the shell. The great objection to this is that one cannot be sure that the shim is supporting the shell save at the bottom. The shell may break as a result.

Bearings Should Be Scraped In

High bearings should be scraped until they are as low as the worn ones. This is an easy job and a scraper can be made of an old flat file. The edges are ground off square and will cut the babbit without any trouble.

After scraping the high bearing all should be measured or "miked" to get them to agree. Upon being placed in the housing, lampblack, prussian blue, or red lead should be smeared lightly over the shaft. At all points where the shaft touches the babbit, the coloring will rub off onto the babbit. By removing the shells again, these high spots may be scraped to bring the babbit in contact with the entire journal. After the lower bearing shells are adjusted, the upper shell or cap must be replaced with running clearance.

Just how much clearance is necessary between the shaft and cap is a question. It is safe to make this 0.01 in. for shafts up to 6 in. in diameter and 0.007 in. for larger shafts. There is no reason for clearance at the top save clearance for the oil film and to provide for the expansion of the shaft by reason of the working temperature.

Low Bearing Will Cause Distortion of Crank Webs

A third method of detecting low bearings has come into general usage in England. This method assumes that a low bearing will cause the width between the crank webs to change by the deflection of the shaft, when the engine is turned so that this particular crank is at top center and then at bottom center. By measuring between the webs, by means of an inside micrometer, any change in the width may be detected at once. If the crank to the right of this crank also shows a deflection, it is proof that the bearing between the two cranks is low. On the other hand, if the crank to the left shows a deflection while the one to the right does not, then the left bearing is low. This method is excellent, but the engineer must be careful in taking the measurements. It is necessary in most cases to remove the connecting rods, but if the flywheel overhangs, removing the weight of the rods and pistons will cause the shaft to bend, thus giving incorrect measurements.

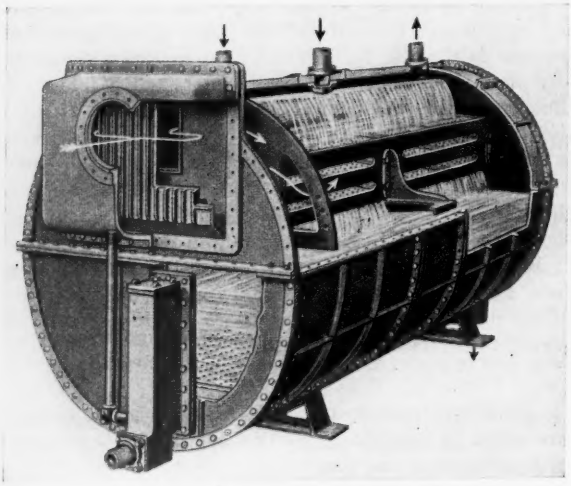
Increases in several lines of electrical apparatus are noted by the Electrical Division of the Department of Commerce in the preliminary figures showing United States exports of electrical equipment during July. The total for the month, however, indicates a slackening off of export shipments, due possibly to the mid-summer decrease in business activity. Shipments of 179 farm lighting outfits were made during July, valued at $52,571. Both of the larger classes of motors were important items, 1880 of the 1 to 200-hp. size, worth $172,002, and 58 valued at $155,061, of the size over 200 hp., were shipped. The seasonal increase in the demand for incandescent lamps resulted in exports of $84,769 worth of metal filament lamps in July. Under the group "Signal and Communicating Devices," the item railway signals and appurtenances is interesting, the amount shipped—$124,359 worth—being more than double that of any previous month of this year. Total exports of electrical machinery, apparatus, and appurtenances in July, 1922, were valued at $5,072,384, compared with $6,023,461 in July, 1921.

Man is said to be only a cog in the machine called life. That is all right if the cog does not slip.

De-aerating Heater Reduces Tube Corrosion

WATER ordinarily contains oxygen in solution, which is set free when the water is heated and will then energetically attack iron and steel pipes in hot water heating and supply systems, and the tubes of steel tube economizers and boilers. The fact that dissolved gases become insoluble when water is heated to the boiling temperature, corresponding to the pressure suggests a direct and easy way of removing the oxygen and thus rendering the water non-rusting and non-corrosive.

Open heaters receiving sufficient exhaust steam at all times to bring the water up to 212 deg. F., or above, greatly reduce the corrosion, but since the amount of heat recovered by the economizer depends upon the difference between the temperature of the flue gases and the temperature of the water, it is desirable, in the interests of overall plant economy, to supply water to economizers at the lowest temperature which will not cause sweating and external corrosion. Ordinarily the



HEATER SUPPLYING OXYGEN FREE WATER

flue gases enter the economizer at a temperature between 550 deg. and 650 deg. F. and leave at a temperature between 250 deg. and 350 deg. F., having therefore a mean temperature of about 450 deg. F. If the feed water enters the economizer at 200 deg. F. and leaves at, say, 300 deg. F., giving a mean temperature of 250 deg. F., the average temperature difference will be in the neighborhood of 200 deg. If, on the other hand, the water enters at 140 deg. or 150 deg. F., the temperature difference and, therefore, the fuel saving and money return upon the economizers, will be increased by 20 per cent or so.

The problem of heating water to the full temperature of the steam in an open heater resolves itself into that of removing non-condensible gases from the steam space. If the venting is done directly from the steam space, large quantities of steam must be vented in order to keep down the concentration of air.

Water Must Be De-aerated in Vacuum for Temperatures Below 212 Deg. F.

If the amount of steam supplied is insufficient to heat the water to atmospheric boiling point, the temperature of the feed water will vary according to the relative amounts of steam and water, and in order to secure de-aeration at the lower temperatures, means must be provided for maintaining a vacuum in the heater corresponding to the pressure of water vapor at the temperature to which the water is heated. This condition will be fulfilled if the accumulation of non-condensible gases in the heater is prevented, as by withdrawing a portion of the heater atmosphere continuously by means of a steam jet air pump or ejector. For operation under vacuum conditions, a vacuum de-aerating heater as illustrated has been developed by the H. S. B. W.-Cochrane Corporation, of Philadelphia. This heater delivers oxygen-free water at any temperature desired in economizer service.

The water to be de-aerated is first sprayed over trays and then falls into a storage space or pool. The steam used for heating the water is introduced through a perforated manifold at the bottom of the storage space. It bubbles up through the water in the storage space carrying up with it any gases which may have been held either in solution or as small bubbles in the water. The steam then heats the water which is coming down over the trays, passing up through the trays counter-current to the flow of water and carrying with it non-condensible gases, which are withdrawn from the top of the tray stack by an air pump or ejector, the discharge of which is condensed in a small closed or tubular heater through which the cold water passes on its way to the de-aerating heater.

A vacuum is carried in the heater corresponding to the final temperature to which the water is heated and advantage can be taken of this vacuum in the operation of auxiliaries, such as house turbines, provided the latter are designed for vacuum operation and the exhaust steam piping system is tight.

If it is desired, however, to operate the auxiliaries under atmospheric pressure, while the water is to be delivered from the heater at a lower temperature, as at 140 deg. F., a flow valve is installed in the exhaust line. This acts as a dam, maintaining atmospheric pressure in the exhaust line and allowing steam to pass to the heater only when the pressure in the exhaust line tends to exceed a fixed minimum, as one or two pounds gage. With this arrangement the temperature of the water will vary, rising and falling according to the relative amounts of water to be heated and steam available. It therefore gives an automatic heat balance without the use of the usual automatic control devices, such as interconnection of the house turbo-generator with the main bus bars, automatic control of the steam supplied to the house turbine, etc. It is also possible to operate the de-aerating heater to deliver water at a fixed temperature.

Water showing zero oxygen by the Winkler test is obtained at commercial rates of operation by this process. The cost of operation, that is, the amount of steam required for the air ejectors, is the same as with any other de-aerator from which the same amount of air is withdrawn at the same temperature and pressure.

Automatic Control of Water Flow

THERE ARE many industries in which large quantities of water are utilized, the flow of which it would be desirable to control between limits, automatically.

Such a control system has been successfully installed upon the outlets of the sand filters of a large Western industry. At the plant in question, the quantity of fresh water used is in the neighborhood of 3,000,000 gal. in 24 hr. This water is hauled by means of tugs and barges some 15 mi. from a reservoir or river. At the refinery it is taken by two 1300-g.p.m. centrifugal pumps and forced through eight sand filters. Three of these sand filters have an area of 160 sq. ft. of filtering surface and a capacity of 500 g.p.m., while the other five filters have an area of 50 sq. ft. and a capacity of 150 g.p.m.

In order that each filter may do its proportionate share of the work it is highly desirable that the output from each be within the limit of its capacity and also up to its capacity. It is also highly desirable to prevent the forcing of more water through any filter than its rated capacity for the reason that when such is the

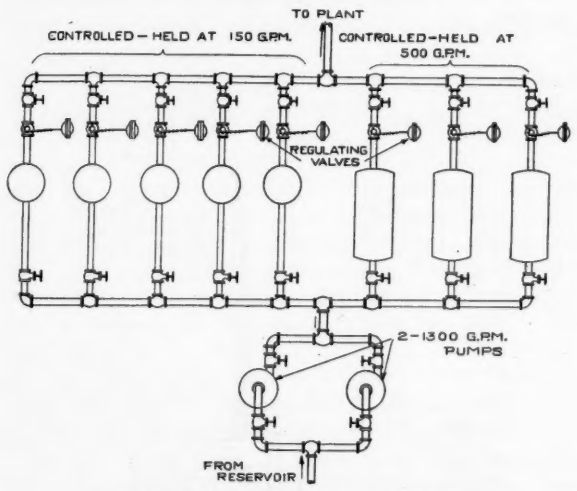


FIG. 1. DIAGRAM OF FILTER LAYOUT

case, the sand and gravel beds become disarranged and the sand gets out into the system.

Hand regulation and manipulation of the outlet valves of these filters is impracticable, due to the fact that the altering of the valve setting on one will affect that of the others.

The problem of so controlling the delivery of these sand filters that the output from the three large filters is 500 g.p.m. and from the five small ones 150 g.p.m. was solved by the installation of the automatic regulating valve as shown in the accompanying sketch. This is a butterfly valve, which is operated by the rod attached to a rubber diaphragm inclosed in a chamber.

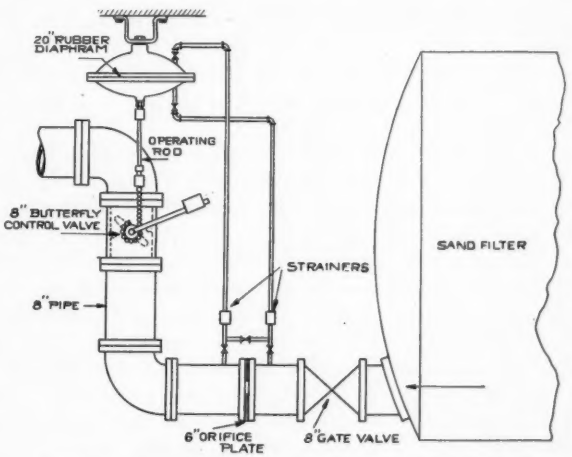


FIG. 2. AUTOMATIC CONTROL VALVE CONNECTIONS

The upper side of the diaphragm is connected to the trailing side of an orifice disk and the lower side to the leading side of the disk.

As the quantity of water passing through the orifice disk is increased above a pre-determined quantity or rate, the diaphragm draws up the operating rod which closes in on the counter-weighted butterfly valve until the flow is cut down to normal. For a decrease in flow, the action is just opposite.

By means of this arrangement, the rate of flow through the water filters is kept at a pre-determined value and as each filter is doing its proportionate share of the work, a more even filtration results with the most efficient use of the filtering capacity installed.

C. C. BROWN.

Can Efficiency Be Determined by Flue Gas Temperature Alone?

ON ACCOUNT of having moved about a bit, I have just now read J. R. Darnell's criticism, on page 821 of the August 15 issue, of my article on this subject which appeared in the Jan. 1, 1921, issue of Power Plant Engineering.

All that Mr. Darnell says is good sound engineering, nevertheless, I believe that, in general, it is possible closely to approximate the efficiency of a boiler by simply taking the flue gas temperature. My formula was derived from a great many reports of actual tests on all kinds of boilers, and I notice that regardless of the

make or type of boiler the results obtained were fairly consistent in every case—consistent enough that I am still unshaken in my contention.

It is true, as Mr. Darnell points out, that there are other losses, such as the loss due to moisture in air, due to CO, and due to radiation, etc.; but according to statistics, these losses seem to be fairly constant in the average plant, whereas the losses due to scale and soot are the variable losses and are in general the principal causes of high flue gas temperatures. Moisture in coal, hydrogen in the fuel, moisture in the air, combustible matter in the ash. radiation and convection, do not influence chimney gas temperature as markedly and as regularly in the average boiler plant as do scale and soot.

It is quite possible, to be sure, that plants can be found in which the formula which I have developed would not work at all; but in the "average" plant, I believe that Mr. Darnell will find that it is a pretty fair indicator of boiler efficiency.

Some years ago when gas and oil engines were fairly new, a scientist came out with a method for determining the efficiency of an internal combustion engine by simply analyzing the exhaust gases. It was claimed that his method was surprisingly accurate and the writer can see no reason why it should not be. In the case of steam power plants, there is no question but that boiler efficiency could be accurately determined by first making a careful analysis of the coal and then a careful analysis of the chimney gases, together with the temperatures of all products leaving through the chimney. The difference would be the heat going through the steam pipe plus the radiation loss together with a few other minor losses. Such a method, however, would be too tedious and impractical. The engineer who wants a good rough indication of his boiler efficiency would rather simply go to his chimney and take a single reading of the chimney gas temperature.

W. F. SCHAPHORST.

Substitute for Crab Claw Spring

MANY are the times that in the smaller and less well regulated power plants, where, on account of overloads, a breakdown must be met by a repair as quickly as the breakdown itself occurs.

Then, too, as in the case of the particular plant I have in mind, the repair must be accomplished without shutting down the offending piece of machinery.

These are the kind of repairs that develop the engineer's mind, make him the man that can "turn the trick" and open the way to him for better things. The man who can cope with these situations must know the operating principles upon which his machinery functions, the theory lying back of the moving steel; he must have an imagination sufficient to conceive of something entirely different, in other words, instead of a direct repair to the broken part, a way of getting around and doing without, and last of all the determination to conquer.

Sketch No. 1, for example, shows a scheme that saved a 200 hp. Corliss engine from shutdown. The valve gear is of the typical crab claw type familiar to most engineers. The upper part of the crab claw held, so as to trip on the trip block, by a piece of spring steel bent in the shape of an elongated "U," wedged at the fulcrum of the unit as shown at "A." Troubles never come single-handed; this trouble was barely located when the spring on the other steam valve did the same trick. The engine, of course, began to knock, as sometimes the valves would not open and then again they would open for the whole length of the stroke. Something had to be done quick and without shutting down.

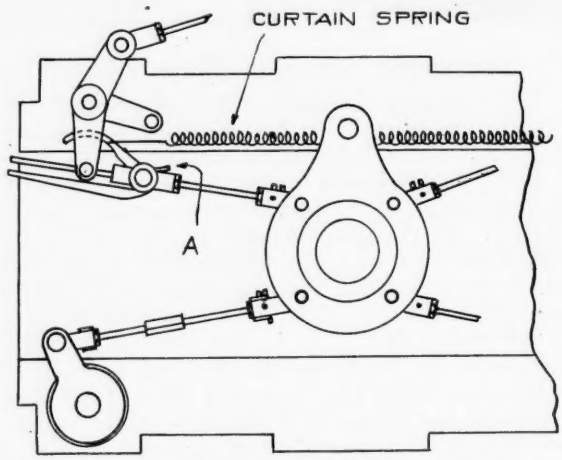


FIG. 1. CURTAIN SPRING USED TO HOLD CRAB CLAW IN POSITION

To get the required tension on the crab claw so that it would pick up and let go according to Hoyle, was the problem. The first thought, to put something in the place of the broken member, was blocked because the broken pieces could not be removed. Two pieces of copper wire and a curtain spring were arranged, as shown.

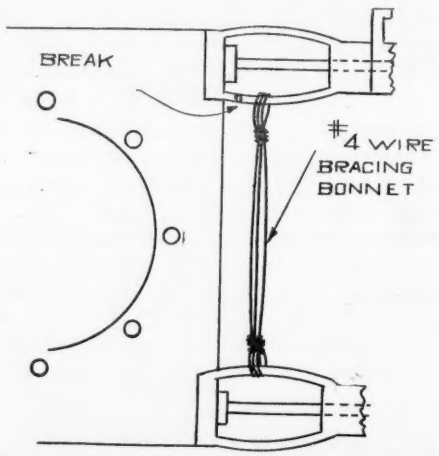


FIG. 2. TEMPORARY REPAIR FOR BROKEN STEAM VALVE BONNET

tied between the two hooks. This repair worked satisfactorily for four days until new spring coils could be made and placed in position.

Sketch No. 2 shows the bottom member of the steam bonnet on the same engine, broken in the place indicated. It was tied in place by the means of wire and run for over a week until we had time to weld it.

J. B. FICKLEN.

Working Under a Master Mechanic

ONE OF the trials and tribulations that some chief engineers have to put up with, is that of working under a master mechanic. I do not say that this condition of employment is always a trial or tribulation, but it is a common condition.

The writer's experience on the road gave him a fair insight into the why and wherefore of this matter. I have found in my travels plants in which the chief engineer had absolutely no authority of any sort, in spite of the fact that the law gives him absolute authority over that particular plant, and my finding on the plant operation where this condition existed is that the plant suffers.

There is in the City of Fall River, Mass., a low pressure turbine taking steam from a cross compound engine. This equipment is located in a large mill. In this mill a master mechanic has authority over the chief engineer. This master mechanic gave orders while the chief was away upon his vacation, whereby the auxiliary steam units which had all formerly exhausted into an open heater were arranged to exhaust into the low pressure inlet steam pipe. This turbine was already getting more steam than she needed from the cross compound engine. Within two days, it was noted by the firemen that the boilers were lying down, and that the fuel oil consumption had increased. The boilers were shut down and baffles were inspected; to do this, it was necessary to shut down a part of the mill, much to the annoyance of the superintendent. Nothing developed from this inspection, and to clear himself the master mechanic expressed the opinion that the oil had been changed. Investigation of this matter brought out the fact that the same grade of oil was in use as had always been used.

Two weeks later, the chief engineer returned to his job and was escorted by the master mechanic to the office, where the master mechanic before the superintendent charged the engineer with tampering with the engine valves before leaving the plant. The chief suggested to the superintendent that if they would come to the power plant he could and would show them the cause for the present poor service. The chief had already been to the engine room and had located the trouble. When they arrived in the engine room, he at once took them to the thermometer on the feed line, and there explained just what the change in the exhaust piping had done to the temperature of the feed water, much to the master mechanic's humiliation. It was not hard to convince the superintendent that the dropping of the feed water temperature 90 deg. was a mighty poor proposition.

In this same plant there are four CO_2 recorders. These instruments, if the manufacturer's instructions are followed, are good machines. The chief engineer took particular pride in the instruments, and made it a point to look after the machines personally. One day the master mechanic, without consulting the engineer, took it upon himself to take the machines apart. In trying to put them together again, he fell down, and therefore went to the engineer who absolutely refused to have anything more to do with the machines. The injustice in this matter was that in time the matter came to the office, and the superintendent failed to see the engineer's point in his resenting the master mechanic's messing with the instruments. ARTHUR D. PALMER.

Providing for Water Around Furnace Door

I HAVE a one-piece furnace lining under my boilers. I always used to have trouble with the center and side piers supporting the door arches giving out too quickly from hitting the piers with the coal shovel and slice bars, thereby wearing away part of the piers as shown in Fig. 1, A, B, C, D. This would weaken the piers considerably causing damage of the entire front furnace lining dropping down, which made it necessary to renew the front furnace lining frequently due to the fact that the piers only were worn away as shown. The widths of the arch piers next to the fire door openings were always made larger next to the furnace than at the doors as shown in Fig. 1.

The last time the lining was renewed, I had the door openings made as shown in Fig. 2 in a straight line; after this we got much longer service out of the

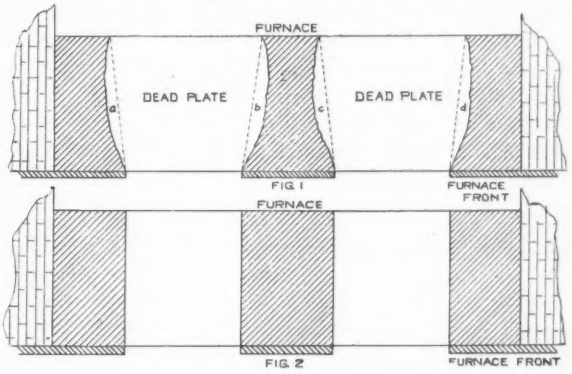


FIG. 1. PLAN OF FURNACE FRONT SHOWING WORN SURFACES
FIG. 2. REVISED DESIGN OF FURNACE FRONT

lining due to the fact that there was much more material at the fire door openings which it took so much longer to wear away by striking it with the fire tools before the piers were worn to such an extent that there was danger of the front arches coming down. In this case, in making the door openings as wide in the rear as in the front did not interfere with throwing coal into the furnace as there still was sufficient room.

H. A. JAHNKE.

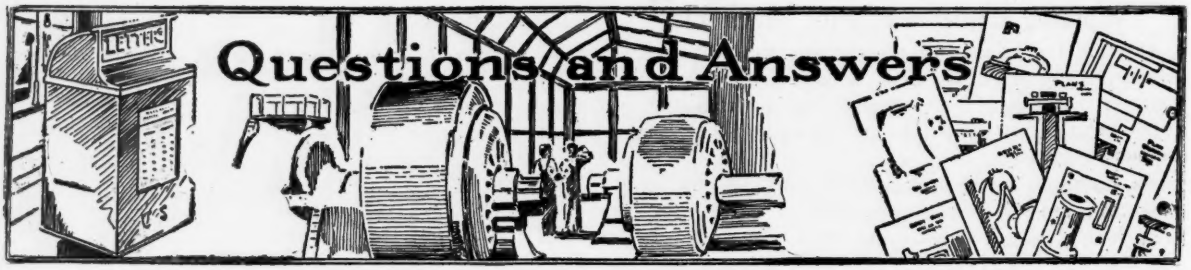
Measuring Outside Diameter Without Calipers

HAVING recently to measure the outside diameter of a pipe in power house where calipers were not instantly available I devised the quick and reasonably accurate method which follows:

I tied two nuts to the ends of a piece of string and threw one of them over the pipe. When they stopped swinging, it was a simple matter to measure the distance between the cords, which was the outside diameter of the pipe close enough for any ordinary purposes.

This can be used on a shaft when not practical to measure in the ordinary way. C. F. RYE.

IN THE UNITED STATES, as compared with Great Britain, our nearest competitor, says Machinery, production per man is 2.6 times as great, the output per man is twice as great, and wages correspondingly higher. The cause is found in the fact that we use three times the mechanical horsepower per worker that England does.



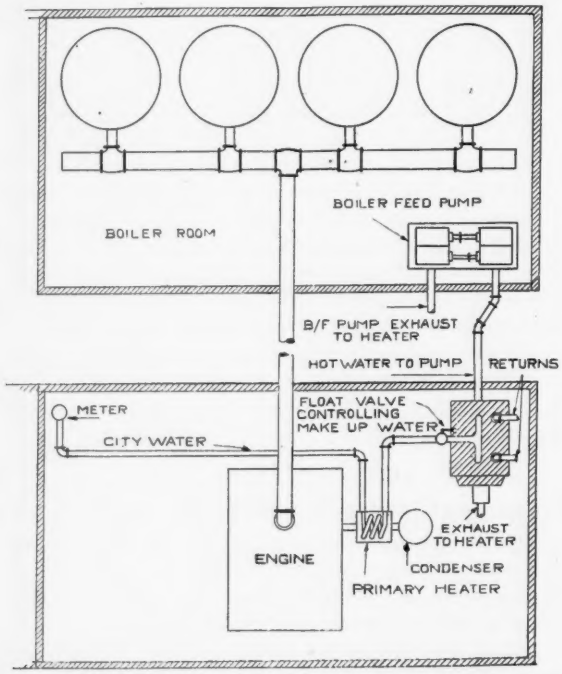
Lap on a Corliss Valve

WHAT IS the definition of lap on a Corliss valve? How is it measured? Why is it that there is no lap required on the steam valve of a double eccentric Corliss engine while on a double eccentric Greene engine, lap is necessary. Any information that will make this matter clear to me will be appreciated.

B. S.

Change in Boiler Feed Piping

THE PROBLEM presented by J. B., in the Oct. 1 issue, is a mighty interesting one, and one that presents a number of different factors and angles which ought to be carefully studied before any change is made.



PROPOSED ALTERATION IN BOILER FEED PIPING

The idea of doing away with the returns pump, and installing a tank is a step in the right direction, for in this way the pump is eliminated and better conservation of hot returns is effected. If the tank is installed it is a question whether it would not be better to install the tank in the present engine room, leaving the feed pump where it is. This, for the reason that to secure the best results and to take full advantage of the returns coming back, J. B. should provide the cold raw water inlet to the tank with a regulating valve so that at those times where the returns are coming back in large quantities, the supply of city water (which, being metered, probably is costly) can be automatically closed off, sufficient city water being admitted to make up only the deficit. On the revised layout shown, no provision is shown to take care of this important matter.

The proposed arrangement does have the advantage of bringing the feed pump near the boiler room, which is of advantage.

It occurs to the writer, however, that a more efficient and convenient layout might be obtained by installing an open heater. This may require an investment; but it must be considered that under the proposed scheme a tank would have to be purchased, a cold water float control and valve for it, to say nothing of the installation cost, and the cost of making the change-over.

The writer's scheme is outlined in the accompanying sketch. City water comes through the primary heater to the regulating valve on the heater, which valve admits only enough make-up to supplement the returns which are also pumped right into the heater. If the returns are cool, they may be passed over the heater trays; if hot, they may be discharged directly into the water space. The heater would take the exhaust from the feed pumps and condenser pumps, and being fitted with an oil separator, this exhaust would go to make up the feed supply, and save considerable city water make-up.

On this sketch it may also be seen that the feed pump is set over in the boiler room, taking its suction from the heater. There is no need for the pump being near the heater if the proper head of water can be had on it, and the logical place for the pump is right in the boiler room. If full size generous piping is used, and a standpipe is erected at the pump intake, there should be no difficulty in pumping the hot water under these conditions.

This scheme effects the greatest possible conservation of the returns, and exhaust; presents a compact layout; eliminates the returns pump and tank; and also allows the feed pump to be located where it belongs, in the boiler room. It requires the purchase of a new heater, but this would probably not cost any more than the other changes contemplated. M. A. SALLER.

Nominal Horsepower

WHAT IS the so-called nominal horsepower of a steam engine? How is it determined? G. A.

A. On examining the equation for horsepower developed by an engine, hp. = PLAN ÷ 33,000. We see that the indicated output depends on P, the mean effective pressure; L, the length of stroke; A, the area of

the piston, and N, the revolutions per minute. P, the mean effective pressure, in turn depends on the initial and back pressures, the quality of the steam and the point of cutoff. The bore and stroke of a given engine are of course known, but to say, for instance, that a 12 by 18-in. engine is rated at 100 hp., without knowing anything of the other factors involved, means nothing. To say, on the other hand, that a 12 by 18-in. engine using dry steam at 125 lb. pressure and exhausting to atmosphere is rated at 100 hp. means a perfectly definite thing. Here, it will be noticed, nothing is said of the cutoff. The cutoff is assumed, however, at the point that will give the best economy and this point will vary with different engines, ranging, perhaps, from 10 to 50 per cent of the stroke. In order, then, to determine the rated power of an engine under any set of conditions, it is necessary to find the point of cutoff that will give the lowest water rate in pounds of steam per indicated or brake horsepower developed. The power developed at this cutoff may then he found by indicating the engine and finding the mean effective pressure and then substituting this value in the equation

$$\text{hp.} = \text{PLAN} \div 33.000.$$

If means are not at hand for finding the actual mean effective pressure or the brake horsepower, a theoretical mean effective pressure may be obtained for any given initial and back pressure, and cutoff from a table which may be found in any engineering handbook.

Hot Air Furnace Efficiency

How WOULD you figure the efficiency of a hot air furnace, fired with an artificial gas of 500 B.t.u. per cu. ft.? Cold air enters the furnace at a temperature of 70 deg. F. with a velocity, as measured by a manometer, or 450 ft. per min. The area of the cold air duct is 0.545 sq. ft. The discharge temperature is 210 deg. F. Gas was being used at the rate of 105 cu. ft. per hr. J. P. D.

A. Efficiency is, of course, equal to the heat absorbed by the air, divided by that supplied by the fuel, over a given length of time, say an hour. If the air enters the furnace through a duct having an area of 0.545 sq. ft., with an average velocity of 450 ft. per min., the quantity of air handled is the product of these two, or $Q = 450 \times 0.545 = 245$ cu. ft. per min., or $245 \times 60 = 14{,}700$ cu. ft. per hr. Air at a temperature of 70 deg. F. weighs approximately 0.0749 lb. per cu. ft., or 13.35 cu. ft. weigh one lb. The quantity handled in pounds is, then, $14{,}700 \div 13.35 = 1100$ lb. per hr. As the specific heat of air is about 0.2375, the heat absorbed in being heated from 70 to 210 deg. F. or through a range of 140 deg., will be $H = 1100 \times 0.2375 \times 140 = 36{,}500$ B.t.u.

As 105 cu. ft. of 500 B.t.u. gas is used per hr., the heat supplied is $105 \times 500 = 52{,}500$ B.t.u. per hr. The efficiency of the furnace is, then, $E = 100 \times 36{,}500 \div 52{,}500 = 69.5$ per cent.

It should be noted, as a matter of accuracy, that the specific heat as given is for dry air. If the air contains any moisture, as it usually does, this moisture will also have to be heated, more heat will be absorbed and consequently the efficiency will be higher. Suppose for instance, that the humidity of the air is 50 per cent, it then contains 55 grains of moisture per pound. Assuming that the specific heat of this moisture is, say, 0.50, then the heat required to raise temperature of that amount contained in a pound of air, 140 deg. will be $55 \div 7000 \times 0.50 \times 140 = 0.55$ B.t.u., (7000 is the number of grains in a pound), and the hourly quantity will be $0.55 \times 1100 = 605$ B.t.u. The total heat absorbed will then be $36{,}500 + 605 = 37{,}105$ B.t.u. and the efficiency $37{,}105 \div 52{,}500 = 71$ per cent.

Starting a Condensing Engine

How SHOULD one proceed to start up a cross compound condensing engine with an independent condenser? J. B.

A. The practice in starting up a condensing engine with independent jet condenser varies according to the nature of the load, and the conditions for starting. If an engine has to start underload the condenser should be started first, so that the power due to the vacuum may be available in helping the engine pull up to speed. If an engine is started without the load on, it is usually better to start up the engine and let it warm up non-condensing, exhausting through the relief valve to atmosphere, then start up the condenser, and as the load is thrown on, put the vacuum on the engine. The engine should not be started up connected to the condenser, with the condenser idle, and vacuum should always be pulled in the condenser before the engine is allowed to exhaust into it, otherwise there is possibility of the water from the condenser flooding back into the exhaust pipe and even reaching the cylinder, which would, of course, be disastrous.

Change from Condensing to Non-Condensing

AS OUR plant is at present operated, our engine exhausts into a condenser but we should like to make a change and use our exhaust for heating purposes. How should this change be made and what effect will it have on the economy and capacity of the plant? W. H.

A. To change your engine from condensing to non-condensing operation in order that you may use exhaust steam in your heating system, it would simply be necessary to tap into the exhaust line to the condenser and put in a lead to the heating main. It is to be supposed that there is now an oil separator in the exhaust line in which case the connection should so made that the separator is between the lead to the heating main and the engine. If no separator is now used, one must be inserted in the line as otherwise oil will get into the heating system and will materially reduce its efficiency.

As it will be necessary to maintain three or four pounds pressure on the system, the atmospheric relief valve will have to be reset for a higher pressure. Some means should also be provided for readily setting this valve to take care of variations of back pressure necessary for changing weather conditions.

By making such a change the back pressure on the engine will of course be increased and the cutoff or the throttle pressure will have to be increased to supply the same amount of power. Considerably more steam will be used by the engine and its economy will be reduced. The overall economy of the plant will, however, be greatly increased and the net result will probably be quite an appreciable saving.

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CONTENTS

The American Printing Co.'s Plant at Fall River. Illustrated 1037
Adapting Coal to the Furnace. By Osborn Monnett....1043
Determining Money Value of Efficiency. By Paul F. Christopher 1044
Looking Ahead in the Fuel Industry. By Floyd W. Parsons 1045
Commercial Value of Exhaust Steam. By Fred William Bosch. Illustrated 1047
Polyphase Wattmeter Connections—II. By L. P. Staubitz. Illustrated....1049
Turning Down the Commutator. By J. B. Dillon....1052
Long Time Element Relays for Large Apparatus. By H. D. Hineline and B. H. Smith. Illustrated....1053
Pumping Engine Efficiency. By Robert Grimshaw....1054
Not According to Hoyle. By Robert Hamilton. Illustrated 1055
Moisture Content of Air. Illustrated....1057
Traps for Boiler Feeding. By H. A. Jahnke. Illustrated.1059
Knocking Around in Texas. By John Pierce. Illustrated 1062
Coal Situation Somewhat Easier....1065
Care of Oil Engine Bearings. By M. S. Howard. Illustrated 1066
De-aerating Heater Reduces Tube Corrosion. Illustrated...1068
Letters Direct from the Plant. Automatic Control of Water Flow. Can Efficiency Be Determined by Flue Gas Temperature Alone? Substitute for Crab Claw Spring. Working Under a Master Mechanic. Providing for Water Around Furnace Door. Measuring Outside Diameter Without Calipers. Illustrated....1069
Questions and Answers: Lap on a Corliss Engine. Nominal Horsepower. Hot Air Furnace Efficiency. Starting a Condensing Engine. Change from Condensing to Non-Condensing. Illustrated....1072
Editorial: Must a Coal Commission Be Created? Interconnection of Central Stations and Industrial Power Plants..1074
Off Duty....1075
Combustible Reclaimed from Ash. Illustrated....1076
New Turbine Placed on the Market. Illustrated....1076
Multicoil Feed Water Heater. Illustrated....1077
New Westinghouse Circuit Breakers. Illustrated....1077
Flash Evaporator Furnishes Pure Make-up Water to Boiler. Illustrated 1078
Practical Refrigerating Engineers Will Meet in St. Louis...1079
Work Will Begin Immediately on New Station of Boston Company 1079
Federal Intervention in Coal Crisis Has Shown Practical Results 1079
Utilities West of Rockies Will Require Huge Investment.1080
Mexico to Get Big Plant for Light and Power....1080
Pit River Plant Now Operating....1080
Ohio Power Co. Will Use Boiler Pressure of 550 Lb....1080
Power Exposition Will Emphasize Importance of Engineer in Present Day Civilization....1081
News Notes 1081
Book Reviews 1082
Catalog Notes 1083

Must a Coal Commission Be Created?

Although the coal situation seems to have passed from a matter of production to a question of transportation, the entire country is watching the general trend of developments with uneasy interest born of past experiences. This anxiety is manifesting itself particularly in regard to prices, which are once more on the up-grade and show signs of running wild just as they did in 1920.

Fortunately the moral suasion which the Federal government was able to exert on the non-union operators during the strike had a marked effect in keeping prices within reason. Elsewhere in this issue some curves of production and prices are shown, which picture the effect of this Federal intervention. Once the strike was over, however, these agreements no longer held, as it was presumed that the traditional law of supply and demand would again function and maintain prices at a reasonable level. To a certain extent this has been the case, due to the movement to confine purchases to current needs.

Recent advances in the so-called smokeless field to $9 a ton at the mine have resulted in further moral suasion, this time through the fuel distributor's office. As a result $6 has been set as a fair price for coal from this field.

The point of all this has been to show the effectiveness of Federal intervention in maintaining prices where the operators themselves were unable to get together.

We do not advocate Federal interference with industry where the industry itself is able to handle its affairs to the satisfaction of the public. In the case of the coal industry, which is just as essential a public utility as the electric light and power companies, it yet remains to be seen whether conditions can be stabilized without a regulating body.

At present the fuel distributor's office has no authority other than moral influence. Possibly conditions may be straightened out without the creation of a permanent and authoritative regulating commission. Let us hope so at least. On the other hand, coal is a commodity that plays too important a part in the efforts of industry and in domestic pursuits to be trifled with and kicked around as the operators and miners may see fit.

Interconnection of Central Station and Industrial Power Plants

Of recent years, a spirit of co-operation has been growing between central stations and industrial power plants which should be fostered to the point where all the power generating equipment of the country will be used to the best advantage of the community in which it is located. Literally millions of dollars are needlessly tied up in the power plants of the country because the lack of co-operation of power producers has resulted in low capacity factor.

Many central stations have load demands placed upon them at peak periods of short duration which require a capacity nearly double that of their average load. At such times, in many localities they could call upon industrial plants, which are underloaded at these periods, to share the load with them and thus eliminate the necessity for equipment required only during peak

load periods and lessen the financial burden of all the power plants able to co-operate in this way.

The question of the advisability of interconnecting central station and industrial power plants is purely an engineering problem involving a study of load curves, demands for exhaust steam, power costs and plant capacities. No unprejudiced engineer questions that under certain circumstances some one type of power plant will give highest over all economy; each type has its place. Nor can there be any question that an interconnection of electric power lines has certain advantages, but the spirit of rivalry between the central station and other power plants has prevented power consumers from securing the full benefits of a system which engineers have for some years recognized as the most economical both from the standpoint of initial investment and use of fuel.

With all the advantages to be had by the interconnection of power plants, we would welcome the extension of this practice which has proved so successful in Fall River, as described in the leading article of this issue, and other communities where it has been tried.

Off Duty

"—I am now working on an engine strong enough to bear 2000 lb. per sq. in.—By the next packet you may expect drawings of my engine, and, I hope, within one short year to take a seat with my friend Dr. Jones by the side of a generator (boiler) sustaining a pressure of 3000 lb. to the sq. in., etc., etc."

So wrote Jacob Perkins of London to a friend, in March, 1827. Think of it! Almost a hundred years ago; yet these "pioneer" engineers discussed the use of steam pressures of 2000 to 3000 lb per sq. in. with an unconcern, to us, almost unbelievable. Why, even today we instinctively shudder at the mere mention of such pressures.

So history repeats itself. Today, we are striving for pressures in the neighborhood of 500 lb.; yet in 1827 Perkins actually operated an engine at 1400 lb. steam pressure! Progress, it seems, occurs in cycles.

The same is true of the progress of civilization. In a recent book, the author shows how in the remote past there have been times when human beings reached comparatively high states of civilization and each time these civilizations declined. These periods he calls cycles. We are now in the seventh cycle of this kind, and have just finished a climb of 1500 yr. to our present high state of development.

Since we, as engineers, have learned that the basis of all prediction lies in the correct analysis of the results of past events, a reading of this book leads us to ask, "What about our civilization? Are we going to follow the same rule? Is our civilization due for a decline?"

Many have pondered over this question lately. The fall of Russia, the critical economic situation in Central Europe, the general state of unrest throughout the entire world—all these things give us cause for apprehension. What do they indicate? Are they merely the aftermath of the war or are they the distant rumblings of a still more devastating storm to come? Time alone will tell.

We have in our possession today, however, something which may deflect the course of our civilization from the downward paths which previous civilizations followed—something which will enable us to continue our progress. This "something" is engineering.

Evolution is not uniform. At certain times sudden changes occur which greatly increase the normal rate of progress. In reviewing the chain of evolution we find in an age of fish, the sudden appearance of amphibians. Immediately afterwards there occurs a great increase in the rate of development. Investigation reveals the fact that such sudden changes are the result of the acquirement of a new degree of freedom. Compared with the fish, the amphibians by virtue of their greater range of locomotion were capable of greater possibilities.

So, today, the human race in a high state of development by virtue of engineering finds itself in possession of a new degree of freedom. Upon the proper use of this new "tool" will depend the future progress or decline of the human race.

Although engineering and scientific knowledge have developed tremendously during the past century, human relations have not. Science and engineering have made the world smaller through developments in communication and transportation. People who for ages had lived apart were suddenly brought into intimate contact. Social, political and economic differences arose and human relations became strained, and, in 1914, the strain became so great that human relations broke. We had war.

Now, we have had wars ever since history began, and while in each case several thousand people were killed, nothing really serious happened. This last war, however, was different. Science showed the warriors a new way—gave them a new gun, a very dangerous gun, and with it, they almost exterminated themselves. In previous wars only the warriors fought; in the last war, the non-combatants did much of the fighting—not in the first line trenches, but in the laboratories thousands of miles from the front.

Future wars may tell a different story. With certain deadly gases, a few aeroplanes will be able to wipe out entire populations of cities. New scientific weapons will be developed which will exterminate the race and destroy civilization.

To save civilization, we must, therefore, apply our engineering knowledge rightly; we must apply it towards constructive purposes. If we do this we will continue to progress. If we do not, the very thing responsible for our development will be the instrument of our destruction.

Power Plant Slogans

Keep and Analyze Operating Records in Every Power Plant.

Develop Water Power Sites.

Promote Health and Safety in Power Plants.

Handle Coal and Ashes Mechanically.

Employ Engineers for Engineering Work.

Combustible Reclaimed from Ash

ANALYSES of refuse boiler furnaces show that the combustible matter which it contains ranges from around 10 to 44 per cent where modern stokers are installed, the average refuse pile containing about 30 per cent of combustible. At the present high price of fuel, it would appear profitable to install some means of reclaiming this unburned fuel in the ash. Like many of our American problems, this one has been met in Europe where the equipment known as the Columbus Fuel Reclaimer has achieved success and is now in use in some 500 plants in Germany.

It will be seen from the accompanying diagram that the apparatus consists essentially of two main parts, these being a revolving sieve drum and an inclined separating trough. The ashes may be fed to the apparatus through a chute from the hopper, but usually the most convenient method is by means of a conveyor.

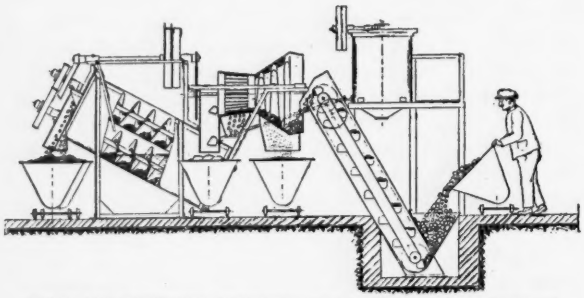


DIAGRAM SHOWING WORKING FEATURES OF COLUMBUS FUEL RECLAIMER

Ashes are fed to the sieve drum which first screens out the fine dust; the remaining material goes over a coarse grid which rejects the large clinker and delivers the fuel bearing material to the inclined separating chamber. This chamber is half filled with a solution of water and clay, sandy loam or any other soil that will raise the specific gravity of the liquid to 25 or more degrees Beaume. Into the separating chamber dip the ends of two screw conveyors which are placed on an incline. The lower conveyor removes the material which has a higher specific gravity than the liquid and is worthless as fuel; the upper conveyor skims the material from the surface of the separating liquid and as this contains all the combustible material that is lighter in specific gravity than the liquid, it is returned to the coal bin for use. The clinkers and clay which are practically free of carbon may be used, it is claimed as building material when formed into blocks with cement. In tests run with ashes from an American power plant containing 30 per cent combustible, the reclaimed portion of the refuse amounted to 35 per cent of that fed to the machine, this ratio, however, may be varied somewhat by changing the specific gravity of the liquid. On an average the heat value of the reclaimed fuel runs about 11,000 B.t.u. per lb., but this also may be varied by changing the specific gravity of the separating liquid. In one instance, using the same sample of ashes, the heat value of the reclaimed fuel was varied from 10,500 to 11,528 B.t.u. The approximate analysis of this fuel shows it to contain from 75 to 80 per cent of carbon, 3 to 5 per cent volatile and the remainder ash. Recent tests on chain grate stokers would indicate that no difficulty should be had in burning this reclaimed fuel mixed with high volatile coal in percentages ranging from 25 to 60 of the total fed to the furnace. These tests also showed that normal boiler room efficiency was maintained and that the resultant ash contained considerably less combustible material.

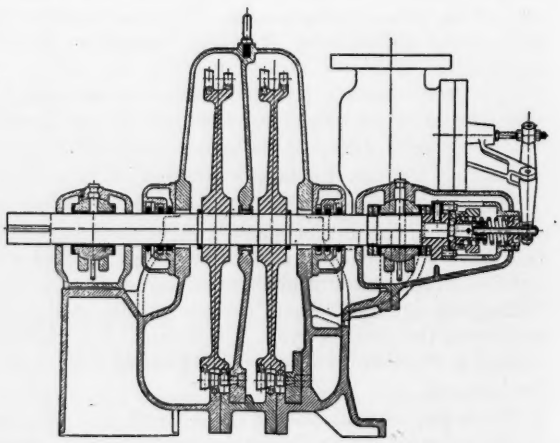
Under present conditions it is estimated that the cost of operating the apparatus including repairs, interest on investment, depreciation, attendance and power cost, would be between $0.60 and $1.25 per ton of reclaimed fuel. Plants of 2000 hp. and up, or those producing 3000 or more T. of ashes a year, can, it is thought, use this apparatus for reclaiming fuel with economy.

Three types of equipment are manufactured by R. Stutzke Co., Chicago, ranging in capacity from 1½ to 12 cu. yd. per hour and requiring from 1 to 4 hp. respectively for operation. Water consumption is from 15 to 40 gal. per hr. The small size apparatus is made portable for convenience in reclaiming piles of ashes not located where they can be easily handled by a stationary installation.

New Turbine Placed on the Market

STEAM TURBINES in ratings up to 600 hp. are now being built by the recently organized Standard Turbine Corporation, of Wellsville, N. Y.

As shown in the illustration, a number of features have been incorporated in the design which are of interest. The bearing on the coupling end is supported



STANDARD TURBINE CORP. WILL BUILD UNITS OF THIS TYPE

on a pillow block resting on a pedestal integral with the lower half of the exhaust end. At the steam end the bearing support is directly under the bearing and is large in diameter, forming a heavy and rigid attachment.

The disks are made in one piece, each carrying two rows of buckets. This construction, although making necessary the use of forgings instead of plate steel, has the advantage that it permits a longer fit on the shaft and consequently reduces the disk stress at the hub. The blading is made from bronze, monel

metal or cupro-nickel depending on the steam conditions.

In designing the governors, the emergency governor has been made entirely independent of the main governor, as is also the emergency governor valve independent of the main valve. Where the main valve is used for an emergency valve, there is always a possibility that wiredrawing will erode the seat and prevent the complete shutting off of the valve when the emergency governor is tripped. By installing an independent emergency valve, this contingency is eliminated.

Multicoil Feed Water Heater

THIS HEATER, of the closed type, has three principal elements,—shell, water chambers and heating coils. The shell is of boiler steel with dished heads and has a door curved to the same radius as the shell with gasket joint secured by stud bolts and constructed to stand the full pressure for which the shell is designed. The studs pass through the shell and are secured against turning by lock nuts on the inside. "Breathing" of the door is prevented by double counterbored openings and lock washers as indicated in Fig. 2.

Heating coils are of seamless copper rolled to shape and coiled in helices to give the maximum heating surface and compel thorough agitation of the water in small streams as it passes through the coils. Either round or crescent shaped section is used, the latter being preferable for high temperature and high velocity. The coils are attached at top and bottom to manifolds, which form a water chamber, by means of copper faced unions. The coil end is flared and is forced against the tapered end of the manifold nipple by a bronze ferrule with scored face, which is backed by a bronze nut. The manifolds are independent of the shell and are bolted to it by flanges which are integral with the external nozzle for water connection, see Fig. 4. All joints are made tight by gaskets, the water connections being held by through bolts.

Openings are provided for safety valve, pressure gage, water gage glass and drain for condensation from the steam. These heaters are made in sizes from 7 in. diameter with 2-in. steam connection up to 63 in. diameter for 14-in. steam connection; the heights range from 60 in. for the smaller sizes up to 84¾ in. for the largest. They are built by the Standard Water Systems Co., of Hampton, N. J.

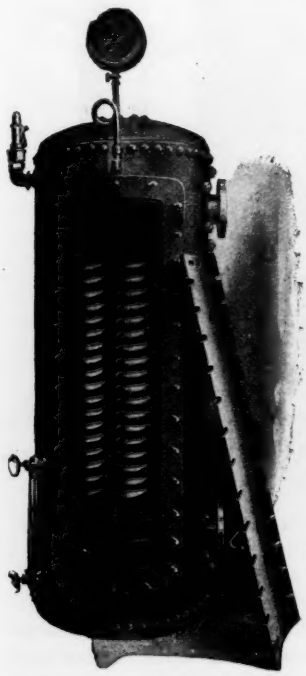


FIG. 1. STANDARD MULTICOIL HEATER SHOWING ARRANGEMENT OF COILS AND HEADERS

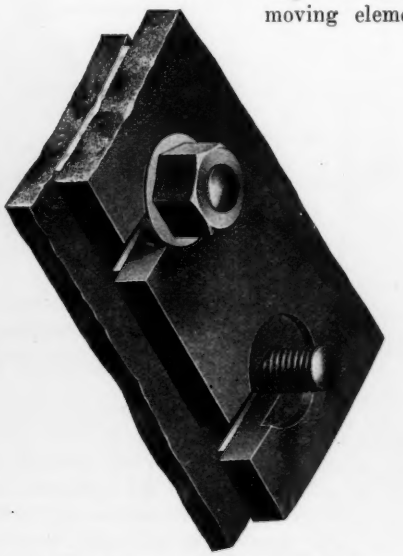


FIG. 2. DETAIL OF JOINT BETWEEN DOOR AND SHELL

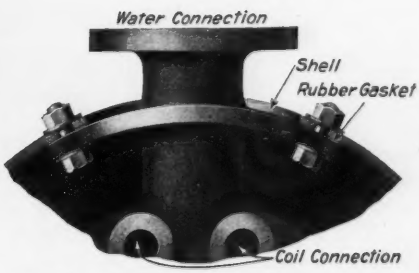


FIG. 3. METHOD OF FASTENING MANIFOLD TO HEATER SHELL

New Westinghouse Circuit Breakers

TWO NEW oil circuit breakers, known as type "F-22," have been added to the type "F-11" line of oil circuit breakers manufactured by the Westinghouse Electric and Manufacturing Co.

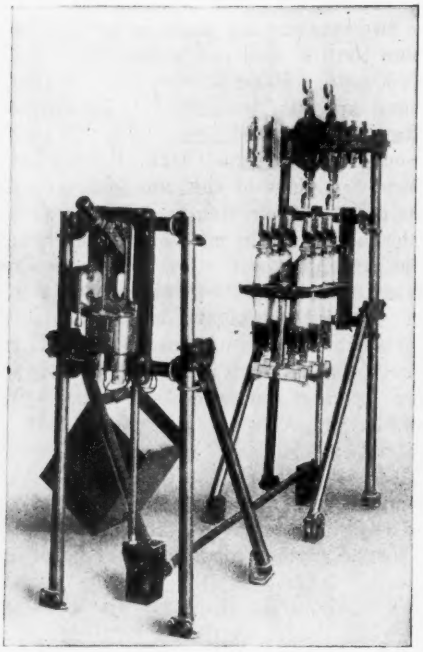
These two breakers are made in the panel mounting and remote control, wall and pipe mounting forms for 400 and 600-amp., 7500-v. service, and 800-amp., 2500-v. service, and are one, two, three and four-pole, single throw, manually operated.

The contact on the type "F-11" breaker is so shaped that different portions of the same contact surface act as the main current carrying contact and as the arcing contact, but arcing on the main current carrying contact surface is prevented by the location of the arcing contact surface. The "F-22" breakers have a wedge and finger contact with auxiliary arcing contacts on the moving element. The stationary element is shaped and located so that different portions of the same contact surface act as the main current carrying contact and as the arcing contact, thus preventing arcing on the main contact surface. All contacts are submerged and opened under oil. The breakers open by gravity assisted by tension springs and are equipped with bumpers to absorb the shock. A panel mounting

breaker can be easily changed to a remote control, wall mounting breaker by adding bell cranks or to a remote control, pipe mounting breaker by the addition of bell cranks and pipe mounting brackets.

For manual operation, the coverplate containing the operating handle is supplied for mounting on a panel or panel bracket. The remote control, wall mounting breakers are designed for upward pull with bell cranks either above or below the floor. The mechanisms can, if necessary, be changed easily from the upward pull arrangement to downward pull without the use of any additional material. The breakers are held in a closed position by a latch on the handle engaging a notch in the coverplate. The lifting of the handle disengages the latch by a movement of the jointed handle and opens the breaker.

Automatic operation is obtained by the addition of one or more automatic trip attachments and of necessary relays and current or potential transformers where



TYPE "F-22" INDOOR, MANUALLY OPERATED, 600-AMP., 7500-V. CIRCUIT BREAKER

needed. All automatic breakers are full-automatic, that is, it is impossible to hold a breaker in the closed position when a predetermined tripping condition exists.

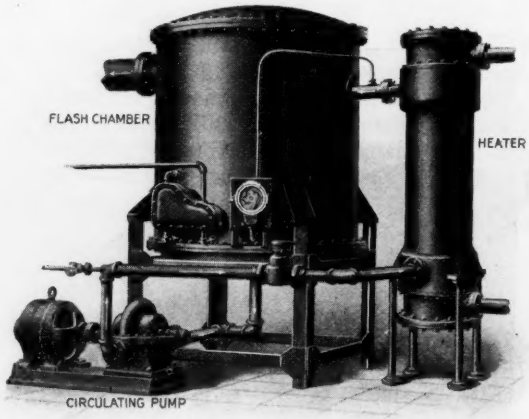
The terminal studs with stationary contacts on the lower end are supported by one-piece vertical pillar type porcelain bushings clamped to the framework by three bolts spaced 120 deg. apart. The studs are clamped in these insulators.

The moving contacts of the type "F-22" breakers are heavy copper castings with renewable arcing tips. The arcing tips are of solid copper with high thermal capacity, which reduces burning from arcing to a minimum.

The stationary contacts consist of fingers of the "controller" type arranged in pairs facing each other so as to make perfect contact on the two surfaces of the moving contact wedge when the breaker is closed. The contact tips on the ends of the fingers are supported on the ends of thin flat steel springs which permit the contact to move in all directions and to aline itself automatically on the wedge, thus making sure that the full capacity of the contacts is always available. This spring is shunted by a liberal copper-leaf shunt to conduct the current from the tips to the terminal stud. The contact pressure is obtained by a second and heavier flat steel spring which rests on a round rivet head and which applies pressure over the center of the contact tip of the finger.

Flash Evaporator Furnishes Pure Make-Up Water to Boiler

SEVERAL operating features of interest are shown in a flash evaporator for the production of pure feed water, which has recently been developed. As shown in the illustration, it consists essentially of a tubular heater, an evaporator proper or flash chamber maintained under vacuum, and a circulating pump. A distilling condenser is also used if the vapor does not pass directly from the flash chamber to the main condenser—otherwise no distiller is required.



WATER HEATED UNDER PRESSURE IN HEATER, FLASHES INTO STEAM IN VACUUM FLASH CHAMBER AND IS THEN CONDENSED IN MAIN CONDENSER

Raw water is heated in the tubular heater to a temperature that is both below the boiling point at atmospheric pressure and also below the temperature at which the impurities in the water are deposited as scale. This temperature, to which the water is heated, is higher than the temperature corresponding to the vacuum maintained in the evaporator. The circulating pump maintains the water in the heater under pressure, and as this heated water enters the evaporator, it flashes into vapor due to the existing vacuum. An automatic feed control valve maintains the water in the flash chamber always at the same level.

The flash evaporator is well adapted for small, as well as large installations. The distillate produced is practically pure water, for even if salt water is used as evaporator feed, the salt content of the distillate is less than 6 parts of salt in 100,000 parts of water.

Distilled water is cheaply obtained because exhaust steam instead of live steam is used in preheating. In plants where there is not sufficient exhaust steam for operating the system, the additional steam required can be taken from the low pressure receiver of the reciprocating engine or from one of the lower stages of the turbine.

Formation of scale in the heater and the precipitation and accumulation of other solid impurities are eliminated, as such scale forming impurities and other salts remain in solution during the entire evaporation process, because of the low temperature at which evaporation takes place, and because no evaporation can occur on the heating surface of the water heater. The system can be operated continuously.

This evaporator not only provides the necessary pure make-up water, but it also supplies this water free from dissolved and entrained oxygen, hence corrosion of boiler tubes, piping and economizer tubes is eliminated.

Internally the structure of the flash chamber is so arranged as to divide the incoming water into a multitude of thin films. This splitting of the water into slices or films is one of the outstanding characteristics of the flash evaporator, and is one of the features wherein it differs from apparatus in which the raw water is ordinarily boiled in a large mass.

The flash evaporator described is manufactured and distributed by the Schutte & Koerting Co., of Philadelphia.

Practical Refrigerating Engineers Will Meet in St. Louis

FROM NOV. 1 to 4, the National Association of Practical Refrigerating Engineers will hold their annual convention at the Planters Hotel in St. Louis. Some 50 manufacturers of refrigerating equipment and accessories will exhibit their products during the days of the convention and it is expected that about 500 members of the association will be in attendance.

At the sessions, numerous subjects of practical importance to the successful operation and maintenance of refrigerating equipment will be discussed. E. H. Fox, 5707 W. Lake St., Chicago, is the national secretary of the organization.

Work Will Begin Immediately on New Station of Boston Company

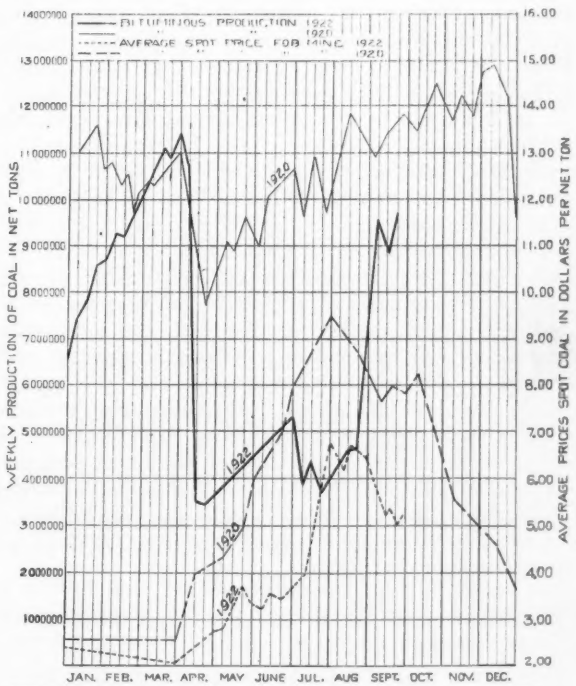
ANNOUNCEMENT HAS been made by C. L. Edgar, president of the Edison Electric Illuminating Co., of Boston, Mass., that work on the Weymouth Station will begin immediately. Preliminary plans call for the installation of two 30,000-kw. turbines with boiler capacity sufficient for one unit, although the station is being laid out for an ultimate capacity of 300,000 kw. It is expected that the new plant will be in service sometime in 1924.

At present the company is installing a 30,000-kw. unit at its L Street Station in South Boston. This will bring that plant up to 186,000 kw. generating capacity and will so fill it that further expansion will not be possible at this site without making radical changes. For this reason it was decided to build an entirely new plant to provide for future growth.

The work will be under the direct supervision of I. E. Moultrop of the Edison company, and Stone & Webster, Inc., has been engaged to design and build the plant in collaboration with the company's engineers.

Federal Intervention in Coal Crisis Has Shown Practical Results

NO CLEARER picture can be obtained of what Federal intervention in the coal crisis has meant than by a study of the accompanying chart of coal production and prices for 1920 and 1922, which has been issued by the fuel distributor's office. From a production standpoint, conditions were far worse this summer than they were during the same period in 1920. Nevertheless prices have been held within reasonable bounds and the wild buyers' panic of 1920 has not been repeated.



PRODUCTION AND PRICES OF COAL FOR 1920 AND 1922 WHICH SHOW EFFECT OF FEDERAL INFLUENCE

It is interesting to note that about six weeks after the strike began a buying wave suddenly raised the spot coal prices to an average of $3.60 a ton. At this point the first effect of possible Federal intervention was felt. The conference called by Secretary Hoover with the intent of restraining prices resulted in a decline of from 60 cents to $1.00 a ton.

In the latter part of May an agreement was entered into with the operators voluntarily to restrain the prices at the Garfield war price plus an amount that would equalize production costs. Late in May, however, certain of the operators refused to continue the price agreement and prices began to advance. On Aug. 10 the governors of several coal producing states decided that the agreement prices should be raised to $4.50 a ton. This brought more operators back in line and the average price receded somewhat. The non-agreement operators were getting as high as $10 and $12 a ton, although the average price at this time was $6.25 a ton.

When the coal strike came to an end on Aug. 15 the voluntary price reductions in nonunion fields also ended. Even so the average price increased but slightly and dropped to about $5.00 a ton on Oct. 1.

Utilities West of Rockies Will Require Huge Investment

POWER COMPANIES west of the Rockies will require at least $750,000,000 in the next decade, to meet the increased service which will be needed, according to James B. Black, general manager of the Great Western Power Co., in a statement issued previous to the convention of Investment Bankers, which was held in San Francisco. Data gathered from 52 companies shows that if their average load curves continue to increase as they have in the past 10 yr., this figure will be a conservative estimate. During 1921, California alone spent almost $150,000,000, which is twice the above-named requirement. It seems obvious, therefore, that more than a billion dollars will be required for this expansion.

In financing these projects, stated Mr. Black, the utilities must have the support of investment bankers, customers, stockholders and all others affected by their operation. In considering the amount to be spent, it should be kept in mind that every dollar invested in public utility securities is spent for labor, material and equipment. The investor in such securities not only receives his regular cash dividends, but also secures an indirect return through employment and prosperity, stimulation of trade and in additional prosperity made possible by the increased power facilities.

In the development of its hydroelectric resources, California is supreme in the United States. California now generates over 10 per cent of the power produced in the entire United States. Even this splendid showing does not represent a large part of the possibilities, as of the 910,000 potential horsepower only about 10 per cent has been developed.

Mexico to Get Big Plant for Light and Power

PLANS FOR the installation by the Mexican Light and Power Co., of a power plant at Beristain, Mexico, which will supply the City of Mexico and cities in the vicinity with electric current for industrial and lighting purposes, were announced recently.

The hydro-turbines for the plant will be furnished by the Pelton Water Wheel Co., of San Francisco, and the two power units will supply 40,000 hp. The first of these units has been completed and shipped to the City of Mexico and freighted into the power plant site.

The present generating plant has been found inadequate, and the construction of the two auxiliary turbines was ordered by the company under financial backing of the Canadian General Finance Co., of Montreal. The advent of the Canadian capital into Mexican business is regarded as opening a new era of business between Mexico and other countries.

Pit River Plant Now Operating

MARKING the first step in the projected $100,000,000 development of the Pit River by the Pacific Gas & Electric Co., the No. 1 plant was formally placed in operation on Sept. 30.

The history of the work dates back to 1917, when the Pacific Gas & Electric Co. purchased the properties of the Mount Shasta Power Corporation, whose activities were centered upon a hydro-project on Pit River at Big Bend. The purchasing company undertook at first to complete this, but conditions arose which brought about a change in plans.

A succession of dry years had almost dried up the Sierra streams, and it was necessary that the company find additional power on short notice. Consequently the Big Bend project was abandoned for the time being and a move was made farther up the stream, which would enable the immediate construction of two preliminary plants on Hat Creek and a chain of developments on the Pit River, leaving the Big Bend as the last link of the chain. The Hat Creek plants were placed in full operation in September, 1921.

For a time it appeared that the land condemnation suit of the Dennis heirs would tie up the plant, but on the day before the plant was placed in service the company paid the $62,500 which had been awarded by the Superior Court; however, the company will push its motion for a new trial, as the award is considered excessive.

Ohio Power Co. Plant Will Use Boiler Pressure of 550 Lb.

PLANS FOR the new plant of the Ohio Power Co., which is to be erected near Zanesville, as announced in the Oct. 15 issue, call for two 35,000-kw. General Electric Co. turbines which are to be operated at 530 lb. steam pressure. The boilers which are to be furnished by the Babcock & Wilcox Co. are to be designed for a working pressure of 650 lb., although the operating pressure will be 550 lb.

The location of the plant will be on the Muskingum River, at Philo, approximately 9 mi. from Zanesville. Sargent & Lundy, of Chicago, are the consulting engineers.

West Penn to Enlarge Springdale Plant

AN ADDITION to the Springdale plant of the West Penn Power Co., which will allow the installation of two 35,000-kw. steam turbine generators will be constructed shortly, according to A. M. Lynn, president of the company. At present the capacity of the plant is 42,000 kw.

Plans also call for the construction of a 132,000-v. transmission line which will tie the Springdale plant in with a line from the Windsor plant on the Ohio River. This new tie line will run from Springdale to Charleroi, where the interconnection will be made. Altogether, the improvement planned will involve an expenditure of $15,000,000.

A. S. M. E. Holds Management Week

MANAGEMENT WEEK meetings, bringing forcibly to public attention the increasing importance of the engineer in industry, were held in thirty cities, Oct. 16-21, under the auspices of the American Society of Mechanical Engineers, the Society of Industrial Engineers and the Taylor Society. With these societies, other engineering organizations and civic and economic bodies co-operated. President Dexter S. Kimball and vice-president L. P. Alford of the A. S. M. E. were among the principal speakers.

Power Exposition Will Emphasize Importance of Engineer in Present Day Civilization

THE NATIONAL EXPOSITION of Power and Mechanical Engineering which is to open at the Grand Central Palace, New York, Dec. 7, for a week, except for the intervening Sunday, will clearly demonstrate to the general public that the engineer is a tremendous force in civilization today. Thousands of individual engineers are daily challenged by the problems involved in the provision of materials for our buildings of steel, cement, and glass which are lighted by electricity, served by mechanical elevators and heated and ventilated by the power and heat from natural sources, but in distinction to the doctor and lawyer these individual engineers do not see their clients. The beneficiaries of their services may be at the other side of the globe.

To show the general public how much it needs the engineer, is a very important purpose of this Exposition. But, further, engineers themselves, to be successful must specialize and few can keep in touch with the great strides that are being made in other fields of engineering than those with which they have immediate contact.

All industries using heat or power in any form will be interested in the displays of steam turbines, steam engines, steam boilers, feedwater heaters, superheaters, economizers, metering devices, stokers, coal handling apparatus, valves and pipe fittings, and the thousand and one important details that enter into a power house.

News Notes

MILO S. KETCHUM, formerly director of civil engineering at the University of Pennsylvania, has been appointed dean of the College of Engineering of the University of Illinois. During the war he was in administrative charge of the construction of the $60,000,000 government smokeless powder plant at Nitro, W. Va. Mr. Ketchum also held the post of dean of the College of Engineering of the University of Colorado from 1905 to 1919, during which time he also acted in a consulting capacity on many construction projects of considerable magnitude.

W. F. RABER, general manager of the Southern Colorado Power Co., has been appointed on the board of directors of the Pueblo Flood Conservancy District. This board will be entrusted with directing such protective measures as will safeguard Pueblo from future floods. Engineers of the Dayton Morgan Engineering Co. are working on the plans and specifications. Railroad engineers suggest that the greatest safeguard would be the building of retaining walls at the mouth of Rock Creek Canyon, 5 mi. west of the city. The cost will be little less than $4,000,000.

WHAT ARE believed to be the first standards for portable electric drills were adopted by the Electric Power Club on Aug. 20 and are printed in its bulletin No. 7900. These rules are the nucleus of a complete group of electric tool standards and what has already been accomplished includes a definition of what constitutes a portable electric drill, test requirements of the motors, performance specifications for drilling, standard sizes of drills, and the information which should be given on electric drill name plates.

THE AMERICAN ASSOCIATION OF ENGINEERS has organized a students' chapter at the Colorado School of Mines, Golden, Colo.

SENATOR RANSDELL, of Louisiana, introduced, in the last session of Congress, a bill to establish a national hydraulic laboratory. While a hearing was held on Sept. 8, no official report has yet been made.

THE BRIER HILL STEEL CO. has sold to a syndicate, headed by the Guaranty Company of New York, an issue of $10,000,000, 5½ per cent bonds, the proceeds to be used in extensions of the plant.

UNFILLED ORDERS of the United States Steel Corporation on Sept. 30 amounted to 6,691,607 T., as compared with 5,950,105 T. on Aug. 31, an increase of 741,502 T.

HAGERSTOWN, MD., will build a new municipal plant with an initial capacity of 3000 kw., to be increased later to 8000 kw. A bond issue of $300,000 has been approved and it is expected that work will begin at an early date.

ANOTHER SUBSIDIARY of the West Penn Power Co., the Monongahela Power & Railway Co., is to spend about $1,000,000 in and around Fairmont, W. Va. Approximately $400,000 of this amount will be used in increasing the capacity of the Riversville plant by 30,000 kw.

PULVERIZED COAL will be used for fuel in the boiler plant of the Norfolk & Western Railroad at Roanoke, Va. The plant, which consists of six 200-hp. and five 400-hp. B. & W. boilers, will be redesigned with this in view. Various grades of coal from the Pocahontas field are to be used, especially bone and refuse coal, varying in ash content from 20 per cent to 38 per cent, with a fuel value of 10,000 to 11,000 B.t.u. The Fuller-Lehigh Co., Fullerton, Pa., has the contract for the redesigning and furnishing the equipment.

A NEW HIGH RECORD for consumption of gasoline in the United States was attained in the month of August, according to statistics compiled by the Federal Bureau of Mines, which show a domestic usage of 583,687,932 gal. Consumption of gasoline in August was 3.1 per cent greater than in July, in which month a record consumption mark had also been established. Consumption figures for this August represent an increase of 16 per cent over the statistics for August, 1921.

Production of gas and fuel oils in August amounted to 944,289,105 gal., which is a slight decrease. Stocks of these oils on Sept. 1 were 1,366,611,311 gal., an increase of about 8,000,000 gal.

THE RICHMOND, VA., office of the Westinghouse Electric & Mfg. Co. has taken quarters in the Virginia Railway & Power Co. building, with W. O. Peale in charge.

C. J. HELLEN, formerly engineer with the Midvale Steel Co., is now assistant to the chief examiner for the City Service Commission of Baltimore, Md.

J. B. CLARK, JR., has recently become associated with the Pennsylvania Crusher Co. as sales engineer, and will make his headquarters at the company's New York office, Hudson Terminal, 50 Church St. For a number of years Mr. Clark has been associated with the Koppers Co., of Pittsburgh, in the erection and operation of

by-product coke plants, including the seaboard plant at Jersey City. Mr. Clark will give particular attention to engineering co-operation in connection with the installation of the company's coal preparation machinery.

THE BROWN INSTRUMENT Co. has opened a Southern branch at Birmingham, Ala., in charge of C. L. Saunders, which will be completely equipped for both sales and service.

GEORGE W. MAPOTHER has been appointed as New York district sales manager for the electrical division of the Johns-Pratt Co., of Hartford, Conn., manufacturers of Noark fuses and protective devices, Vulcabeston packing and insulation and Johns-Pratt molded products. Mr. Mapother will make his headquarters at the New York office of the company, located at 41 East 42d St.

ON ACCOUNT of the growth in business the Metallo Gasket Co. of New Brunswick, N. J., has found it necessary to establish offices at 242 Lafayette St., New York City. A complete stock will be carried at this location and a staff of experts will be available for consultation work.

THE RISHER FIRE BRICK Co., an Illinois corporation with a capitalization of $40,000, has established offices and warehouse facilities at 18th and Canal Sts., Chicago. The company will carry a complete stock of refractories, including special shapes. H. E. Risher is president of the concern.

THE WEST MARYLAND POWER Co., a subsidiary of the West Penn Power Co., has bought the municipal power plant at Oakland, Md. Insufficient capacity of the city plants to meet the local requirements is the reason given for the transfer. As the plant will now be tied in with the extensive net work of the West Penn system, plans call for the extension of service to the coal regions around Crellin on the Youghiogheny River.

GENERATING EQUIPMENT of the new power station to be erected at Grand Tower, Ill., by the Middle West Utilities Co., has been ordered from the Westinghouse Electric & Manufacturing Co. One 20,000-kw. turbine-generator unit, to supply 13,200-v., three-phase, 60-cycle current, will be installed. The operating conditions for the turbine will be 350 lb. steam pressure, 200 deg. F. superheat and 29 in. vacuum.

THE CONVEYORS CORPORATION of America, 326 West Madison St., Chicago, Ill., has appointed the Geo. W. Fife Engineering Co., 1403 Merchants Bank Building, Indianapolis, Ind., its representative for the sale of American trolley carriers in the state of Indiana. The trolley carrier is an equipment for handling coal from railroad cars to bunkers, silos or open storage piles. It consists of an overhead monorail, with a trolley from which a one-ton bottom dump bucket is suspended.

U. S. CIVIL SERVICE COMMISSION announces an examination for laboratory assistant, senior grade, Nov. 8—9, to fill vacancies in the Bureau of Standards, Department of Commerce, for duty in Washington, D. C., or elsewhere, and in positions requiring similar qualifications, at salaries ranging from $1200 to $1380 a year. Appointees whose services are satisfactory may be allowed the increase granted by Congress at $20 a month. Competitors will be rated on general chemistry and elementary physics, mathematics (including differential calculus), an optional subject from a given list, education, training, and experience. Applicants must not have reached their thirty-fifth birthday on the date of examination. This age limit does not apply to persons entitled to preference because of military or naval service, but such applicants must not have reached the retirement age. Apply for Form 1312, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

IMPORTS of electrical and power apparatus by Manchuria in 1921 showed an increase of about 30 per cent over the imports in 1920, according to the American consul. In 1921, imports of such equipment amounted to $1,877,267; America, Japan and England each furnishing about one-third of the apparatus.

INCREASED BUSINESS necessitating increased production and more adequate facilities has resulted in the transfer of the Krantz works of the Westinghouse Electric & Manufacturing Co. to Mansfield, O. The Krantz works has been situated for many years at Brooklyn, N. Y., but, with a gradual increase in business, indicating a return to normalcy, the Krantz officials decided that the Brooklyn works was not large enough to furnish adequate facilities to meet the impending demand for production. The transfer of the Krantz works to Mansfield offers better facilities for increased production and gives the works a location in the central part of the country with easy access to a large number of railroads and to both the Middle West and Eastern offices of the Westinghouse company.

Book Reviews

STEAM ENGINE PRINCIPLES AND PRACTICE, by Terrell Croft; size 5½ by 8 in., 513 pages, 547 illus., cloth; New York, 1922.

Steam Engine Principles and Practice is the latest addition to Croft's Power Plant Series. It is a practical book well adapted to the needs of operating engineers, or plant superintendents. Nothing has been included pertaining to the design of engines; the treatment has been confined to questions of usage. Such information is given as will point out to the reader methods of selecting, operating, caring for, repairing and improving the economy of steam engines. No complicated mathematics is employed; all that is required of the reader for a complete understanding of the text is a working knowledge of simple arithmetic.

All through the text, principles which are set forth are fully explained and are supplemented with illustrative descriptions.

The subject matter is presented under 16 divisions, at the end of each of which are questions and, in some cases, problems. Ability to answer these questions entails a conversant knowledge of the material in the division, so that in this way the reader is able to check up on his understanding of the subject.

After the introductory consideration of the function and principles of the steam engine, there is presented a division on nomenclature and classification which is followed by a treatise on indicators. After this, valves and governors are considered in their various aspects. Following this is a discourse of the economies of con-

densers, multiple expansion engines, etc. The testing of engines is then treated; following are divisions on management, operation and repair and on the use of superheated steam. Division 15 deals with the economic selection of units and the final section, with the important subject of lubrication.

Bountifully supplied with illustrations, in themselves almost entirely self-explanatory, the text is particularly clear even to the uninitiated.

MECHANICAL LABORATORY METHODS, edited by Julian C. Smallwood; size 5 by 7½ in., 423 pages, 112 illustrations; New York, 1922.

This is the third, revised and enlarged, edition of a handbook which covers the methods of testing instruments and machines in the mechanical engineering laboratory and in practice. The work is divided into three main sections: the testing of instruments, the analysis of combustion and the testing of power plant units.

For both the student and the man in operating field, this work should be of considerable value as a ready reference to the use of indicators, planimeters, calorimeters, dynamometers, etc. In the testing of power plant units, steam engines, steam pumps, boilers, auxiliaries, gas engines, refrigeration machinery, air machinery, water motors and miscellaneous tests are covered. Enough theory is presented to give a clear understanding of the methods to be followed in working up computations from the test data.

"THE REHEATING OF COMPRESSED AIR" is the title of Bulletin No. 130, written by C. R. Richards and J. N. Vedder and recently issued by the Engineering Experiment Station of the University of Illinois. The investigation leading to the publication of Bulletin 130 was undertaken to determine the ideal thermodynamic efficiencies resulting from the heat expended in the reheating process, the efficiency of external and internal combustion reheaters, and the performance of an engine operated with air used expansively, with steam alone, and with a mixture of air and steam, the steam being injected into the air pipe as a means of reheating the air.

HYDRAULIC DIAGRAMS for the Discharge of Conduits and Canals, by Swan and Horton; 53 pages, size 6 by 9 in., 17 diagrams, paper; New York, 1922.

These diagrams, based on the formula of Ganguillet and Kutter, are for use in the study of sections of conduits and canals such as are commonly used for sewerage, water supply, water power, and land drainage. Conduits of 10 different types of cross section, and canals of rectangular and trapezoidal sections are included.

THE RESULTS OF analyses of hundreds of coals from 25 states and the Territory of Alaska are given in Bulletin 193, "Analyses of mine and car samples of coal collected in the fiscal years 1916 to 1919," by Arno C. Fieldner, Walter A. Selvig, and J. W. Paul just issued by the United States Bureau of Mines. Information as to the heating values of all coals tested is also given in the bulletin, which should be of interest to all extensive users of coal fuel.

The entire distribution of Bulletin 193 will be through the Superintendent of Documents, Government Printing Office, Washington, D. C., from whom the report may be obtained at a price of 35 c. Bulletins 22, 85 and 123, the previously issued compilations of coal analyses made by the Bureau of Mines, are sold by the Superintendent of Documents at prices 85, 45 and 50 c., respectively.

CLAY PRODUCTS CYCLOPEDIA, edited by Industrial Publications, Inc., size 9 by 12 in., 252 pages; Chicago, 1922.

A valuable addition has been made to ceramic engineering literature, in the publication of this cyclopedia, which covers information of definitions and statistics as well as catalog pages of manufacturers' equipment.

Catalog Notes

BULLETIN No. 910, issued by the Griscom-Russell Co. of New York, covers heat transfer apparatus as used in oil refinery operations.

PORTABLE direct current galvanometers made by Roller-Smith Co., 233 Broadway, New York, are described and illustrated in that company's bulletin No. 250.

SPRAGUE ELECTRIC Type WX hoists, with smooth running worm drive which operates a balanced pair of winding drums, are the subject of a new folder from Sprague Electric Works of General Electric Co., New York.

BALLARD & SPRAGUE, 200 Fifth Ave., New York City, has issued a bulletin covering its construction service on boiler settings and chimneys. Numerous illustrations are shown which give an idea of the type of work handled by this organization.

THE MARTINDALE ELECTRIC CO., Cleveland, Ohio, has issued a 10 by 14-in. chart showing causes and effects of carbon brush and commutator troubles. This chart is put up in a form which will be of great assistance in locating and correcting troubles on direct-current motors and generators.

A CONDENSATION-VACUUM, return line pump and receiver unit with motor and individual automatic control of the water and vacuum, which maintains a vacuum on the return lines of the heating system and returns condensation directly to the boiler, is described in bulletin No. 100, issued by the Hydro-High Vacuum Pump Co., of Newport, Kentucky.

TROLLEY CARRIERS for the handling of coal is a subject which is covered in a folder sent out by the Conveyors Corporation of America, of Chicago. It is pointed out that simple, economical methods of handling coal are needed at the average retail coal yard and industrial plant. Several typical cases are cited, and figures given, in which the economies effected by the trolley system were quite marked.

CUTTING THE COST OF PRODUCING STEAM is the title of bulletin No. 230 recently issued by the Detroit Stoker Co. The bulletin starts with the premise that "One of the conditions necessary to the efficient combustion of coal is the uniform liberation of the volatile gases. This is a condition which practically never can be obtained in the hand-fired furnace. Inasmuch as the hand-fired furnace also represents definite limitations in the way of utilizing the cheapest grades of fuel, engineers are today finding that the way to improve boiler

room operating conditions is to install mechanical stokers." From this point the bulletin takes up the savings effected with stokers, principles of stoker design, and concludes with a section on the service of stokers.

THE LIBERTY MFG. CO., of Pittsburgh, Pa., maker of Liberty tube cleaners, has just published a new 40-page catalog Z-1. The various types of Liberty cleaners are described and illustrated in full detail. Illustrations with names for the different parts of both cleaners and cutter heads will be found especially helpful to users.

THE IMPORTANCE of drafts and draft regulation is covered in a bulletin on that subject, by Jos. W. Hays, of the Jos. W. Hays Corporation, of Michigan City, Ind. A fund of practical information about draft control is presented and the various types of Hays draft gages are illustrated and described.

Another bulletin, "O.K.'d by All Industries," gives reports from users of Hays automatic CO_2 and draft recorders.

A NEW ILLUSTRATED publication, Reprint 118, has recently been issued by the Westinghouse Electric & Manufacturing Co., embracing an article by Professor Chas. F. Scott on the subject, "The Question of Inductive Interference and Electrolysis as Related to Railroad Electrification."

The publication reviews briefly the causes of inductive interference and the remedial measures which have been applied citing definite experiences with alternating single-phase installations. The conclusion drawn is that power transmission circuits with solidly grounded neutral may be expected to produce telephone disturbances of the same kind and of even greater intensity than those caused by electrical railways.

THE GENERAL ELECTRIC CO. has issued Bulletin 46,108, describing the Type M-4 Demand Meter which is manufactured by it and designed for use in combination with a watthour meter to indicate maximum demand. It is of the so-called "block interval" type indicating the maximum demand integrated and averaged over a definite time interval.

The watthour meter integrates the fluctuating values of load and causes the pointer of the demand registering mechanism to advance by increments, in step with it, through the agency of a contact device in its register. A constant speed motor establishes the time intervals. At the end of each interval this motor causes the demand mechanism to be reset to zero ready for the next interval. In doing so, it leaves a friction pointer at the highest point on the scale to which it has been carried during any preceding interval and thus indicates the maximum demand.

THE COMBINED CATALOG issued by the H. S. B. W.-Cochrane Corporation, of Philadelphia, and describing its varied line of open feed water heaters, v-notch meters, metering heaters, flow meters for fluids in pipes, water softeners, including both hot process and cold process, pressure filters, back pressure valves, including valves for atmospheric relief service and flow valves, steam and oil separators and drainers or traps, is a well illustrated book of more than 200 pages and shows several newly developed devices. Among these is a de-aerating heater designed to prevent corrosion of boilers, superheaters and piping by oxygen dissolved in water. In this apparatus the oxygen is driven out of the water while the water is being heated, the heater being operated at a pressure corresponding to the final temperature of the water. Another novel feature appliance is the Cochrane flow meter for measuring flow in pipes.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.,

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for October 1, 1922.

State of Illinois
County of Cook
ss.

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of Aug. 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.

Editor, Arthur L. Rice, Chicago, Ill.

Managing Editor, none.

Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of the stockholders owning or holding 1 per cent or more of the total amount of stock.)

Technical Publishing Co., Chicago, Ill.

E. R. Shaw, Chicago, Ill.

A. L. Rice, Chicago Ill.

K. L. Rice, Chicago, Ill.

Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none.

4. That the two paragraphs next above, giving the names of owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has an interest, direct or indirect, in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is ..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 6th day of October, 1922. Gertrude M. Williams.
(SEAL) (My commission expires August 12, 1925.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.